



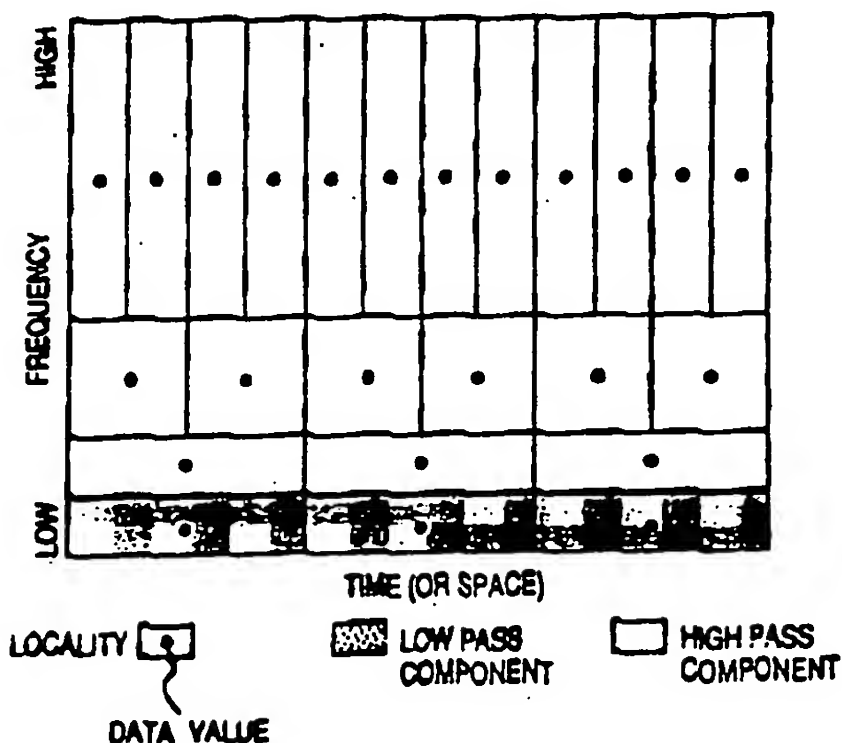
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: DATA COMPRESSION AND DECOMPRESSION

## (57) Abstract

A compression and decompression method uses a wavelet decomposition, frequency based tree encoding, tree based motion encoding, frequency weighted quantization, Huffman encoding, and/or tree based activity estimation for bit rate control. Forward and inverse quasi-perfect reconstruction transforms are used to generate the wavelet decomposition and to reconstruct data values close to the original data values. The forward and inverse quasi-perfect reconstruction transforms utilize special filters at the boundaries of the data being transformed and/or inverse transformed. Structures and methods are disclosed for traversing wavelet decompositions. Methods are disclosed for increasing software execution speed in the decompression of video. Fixed or variable length tokens are included in a compressed data stream to indicate changes in encoding methods used to generate the compressed data stream.



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## DATA COMPRESSION AND DECOMPRESSION

CROSS REFERENCE TO APPENDICES

5 Appendix A, which is a part of the present disclosure, is a listing of a software implementation written in the programming language C.

Appendices B-1 and B-2, which are part of the present disclosure, together are a description of a hardware  
10 implementation in the commonly used hardware description language ELLA.

Appendix C, which is part of the present disclosure is a listing of a software implementation written in the programming language C and assembly code.

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20 FIELD OF THE INVENTION

This invention relates to a method of and apparatus for data compression and decompression. In particular, this invention relates the compression, decompression, transmission and storage of audio, still-image and video  
25 data in digital form.

BACKGROUND INFORMATION

An image such as an image displayed on a computer monitor may be represented as a two-dimensional matrix of digital data values. A single frame on a VGA computer  
30 monitor may, for example, be represented as three matrixes of pixel values. Each of the three matrixes has a data value which corresponds to a pixel on the monitor.

The images on the monitor can be represented by a 640 by 480 matrix of data values representing the luminance

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(brightness) values Y of the pixels of the screen and two other 640 by 480 matrixes of data values representing the chrominance (color) values U and V of the pixels on the screen. Although the luminance and chrominance values are 5 analog values, the one luminance value and the two chrominance values for a pixel may be digitized from analog form into discrete digital values. Each luminance and chrominance digital value may be represented by an 8-bit number. One frame of a computer monitor therefore 10 typically requires about 7 megabits of memory to store in an uncompressed form.

In view of the large amount of memory required to store or transmit a single image in uncompressed digital form, it would be desirable to compress the digital image 15 data before storage or transmission in such a way that the compressed digital data could later be decompressed to recover the original image data for viewing. In this way, a smaller amount of compressed digital data could be stored or transmitted. Accordingly, numerous digital 20 image compression and decompression methods have been developed.

According to one method, each individual digital value is converted into a corresponding digital code. Some of the codes have a small number of bits whereas 25 others of the codes have a larger number of bits. In order to take advantage of the fact that some of the codes are short whereas others of the codes are longer, the original digital data values of the original image are filtered using digital filters into a high frequency component and 30 a low frequency component. The high frequency component represents ambiguities in the image and is therefore observed to have a comparatively large number of identical data values for real-world images. By encoding the commonly occurring digital data values in the high 35 frequency component with the short digital codes, the total number of bits required to store the image data can be reduced from the number of bits that would otherwise be

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required if 8-bits were used to represent all of the data values. Because the total number of bits in the resulting encoded data is less than the total number of bits in the original sequence of data values, the original image is said to have been compressed.

To decompress the compressed encoded data to recover the original image data, the compressed encoded data is decoded using the same digital code. The resulting high and low frequency components are then recombined to form the two-dimensional matrix of original image data values.

Where the data being compressed is two-dimensional data such as image data, separation of the original data into high and low frequency components by the digital filters may be accomplished by filtering in two dimensions such as the horizontal dimension of the image and the vertical dimension of the image. Similarly, decoded high and low frequency components can be recombined into the original image data values by recombining in two dimensions.

To achieve even greater compression, the low frequency component may itself be filtered into its high and low frequency components before encoding. Similarly, the low frequency component of the low frequency component may also be refiltered. This process of recursive filtering may be repeated a number of times. Whether or not recursive filtering is performed, the filtered image data is said to have been "transformed" into the high and low frequency components. This digital filtering is called a "transform". Similarly, the high and low pass components are said to be "inverse transformed" back into the original data values. This process is known as the "inverse transform".

Figure 1 is a diagram of a digital gray-scale image of a solid black square 1 on a white background 2 represented by a 640 by 480 matrix of 8-bit data luminance values.

Figure 2 is a diagram illustrating a first

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intermediate step in the generation of the high and low frequency components of the original image. A high pass digital filter which outputs a single data value using multiple data values as inputs is first run across the original image values from left to right, row by row, to generate G subblock 3. The number of digital values in G subblock 3 is half of the number of data values in the original image of Figure 1 because the digital filter is sequentially moved to the right by twos to process two additional data values for each additional one data output generated for G subblock 3. Similarly, a low pass digital filter which outputs a single data value using multiple data values as inputs is first run across the original image values from left to right, row by row, to generate H subblock 4. The number of digital values in H subblock 4 is half of the number of data values in the original image because the digital filter is moved to the right by twos to process two additional data values for each additional one data output generated for H subblock 4. Each of the two vertical bars in high pass G subblock 3 appears where a change occurs spatially in the horizontal dimension in the original image of Figure 1. Where the G filter encounters a change from white data values to black data values when the filter G is run across the image of Figure 1 in a horizontal direction, the G digital filter outputs a corresponding black data value into subblock 3. Similarly, when the G digital filter encounters the next change, which is this time a change from black to white data values, the G digital filter again outputs a corresponding black data value into G subblock 3.

Figure 3 is a diagram illustrating a second intermediate step in the generation of the high and low frequency components of the original image. The high pass digital filter is run down the various columns of the subblocks H and G of Figure 2 to form the HG subblock 5 and GG subblock 6 shown in Figure 3. Similarly, the low pass digital filter is run down the various columns of the

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H and G subblocks 3 and 4 of Figure 2 to form HH and GH subblocks 7 and 8 shown in Figure 3. The result is the low pass component in subblock HH and the three high pass component subblocks GH, HG and GG. The total number of high and low pass component data values in Figure 3 is equal to the number of data values in the original image of Figure 1. The data values in the high pass component subblocks GH, HG and GG are referred to as the high frequency component data values of octave 0.

10       The low pass subblock HH is then filtered horizontally and vertically in the same way into its low and high frequency components. Figure 4 illustrates the resulting subblocks. The data values in HHHG subblock 9, HHGH subblock 10, and HHGG subblock 11 are referred to as  
15       the high frequency component data values of octave 1. Subblock HHHH is the low frequency component. Although not illustrated, the low frequency HHHH subblock 12 can be refiltered using the same method. As can be seen from Figure 4, the high frequency components of octaves 0 and 1  
20       are predominantly white because black in these subblocks denotes changes from white to black or black to white in the data blocks from which the high frequency subblocks are generated. The changes, which are sometimes called edges, from white to black as well as black to white in Figure 1  
25       result in high frequency data values in the HG, HG and GG quadrants as illustrated in Figure 3.

      Once the image data has been filtered the desired number of times using the above method, the resulting transformed data values are encoded using a digital code  
30       such as the Huffman code in Table 1.

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	<u>Corresponding Gray-Scale</u>	<u>Digital Value</u>	<u>Digital Code</u>
		.	
		.	
5		.	
		5	1000001
		4	100001
		3	10001
		2	1001
10	black	1	101
	white	0	0
		-1	111
		-2	1101
		-3	11001
15		-4	110001
		-5	1100001
		.	
		.	
		.	

20

Table 1

Because the high frequency components of the original image of Figure 1 are predominantly white as is evident from Figures 3 and 4, the gray-scale white is assigned the single bit 0 in the above digital code. The next most common gray-scale color in the transformed image is black. Accordingly, gray-scale black is assigned the next shortest code of 101. The image of Figure 1 is comprised only of black and white pixels. If the image were to involve other gray-scale shades, then other codes would be used to encode those gray-scale colors, the more predominant gray-scale shades being assigned the relatively shorter codes. The result of the Huffman encoding is that the digital values which predominate in the high frequency components are coded into codes having a few number of bits. Accordingly, the number of bits required to represent the original image data is reduced. The image is therefore said to have been compressed.

Problems occur during compression, however, when the digital filters operate at the boundaries of the data values. For example, when the high pass digital filter generating the high pass component begins generating high pass data values of octave 0 at the left hand side of the original image data, some of the filter inputs required by

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the filter do not exist.

Figure 5 illustrates the four data values required by a four coefficient high pass digital filter  $G$  in order to generate the first high pass data value  $G_0$  of octave 0. As shown in Figure 5, data values  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  are required to generate the second high pass data value of octave 0, data value  $G_1$ . In order to generate the first high pass component output data value  $G_0$ , on the other hand, data values  $D_{-1}$ ,  $D_0$ ,  $D_1$ , and  $D_2$  are required. Data value  $D_{-1}$  does not, however, exist in the original image data.

Several techniques have been developed in an attempt to solve the problem of the digital filter extending beyond the boundaries of the image data being transformed. In one technique, called zero padding, the nonexistent data values outside the image are simply assumed to be zeros. This may result in discontinuities at the boundary, however, where an object in the image would otherwise have extended beyond the image boundary but where the assumed zeros cause an abrupt truncation of the object at the boundary. In another technique, called circular convolution, the two dimensional multi-octave transform can be expressed in terms of one dimensional finite convolutions. Circular convolution joins the ends of the data together. This introduces a false discontinuity at the join but the problem of data values extending beyond the image boundaries no longer exists. In another technique, called symmetric circular convolution, the image data at each data boundary is mirrored. A signal such as a ramp, for example, will become a peak when it is mirrored. In another technique, called doubly symmetric circular convolution, the data is not only mirrored spatially but the values are also mirrored about the boundary value. This method attempts to maintain continuity of both the signal and its first derivative but requires more computation for the extra mirror because the mirrored values must be pre-calculated

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before convolution.

Figure 6 illustrates yet another technique which has been developed to solve the boundary problem. According to this technique, the high and low pass digital filters 5 are moved through the data values in a snake-like pattern in order to eliminate image boundaries in the image data. After the initial one dimensional convolution, the image contains alternating columns of low and high pass information. By snaking through the low pass sub-band 10 before the high pass, only two discontinuities are introduced. This snaking technique, however, requires reversing the digital filter coefficients on alternate rows as the filter moves through the image data. This changing of filter coefficients as well as the requirement 15 to change the direction of movement of the digital filters through various blocks of data values makes the snaking technique difficult to implement. Accordingly, an easily implemented method for solving the boundary problem is sought which can be used in data compression and 20 decompression.

Not only does the transformation result in problems at the boundaries of the image data, but the transformation itself typically requires a large number of complex computations and/or data rearrangements. The time 25 required to compress and decompress an image of data values can therefore be significant. Moreover, the cost of associated hardware required to perform the involved computations of the forward transform and the inverse transform may be so high that the transform method cannot 30 be used in cost-sensitive applications. A compression and decompression method is therefore sought that not only successfully handles the boundary problems associated with the forward transform and inverse transform but also is efficiently and inexpensively implementable in hardware 35 and/or software. The computational complexity of the method should therefore be low.

In addition to transformation and encoding, even



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further compression is possible. A method known as tree encoding may, for example, be employed. Moreover, a method called quantization can be employed to further compress the data. Tree encoding and quantization are  
5 described in various texts and articles including "Image Compression using the 2-D Wavelet Transform" by A.S. Lewis and G. Knowles, published in IEEE Transactions on Image Processing, April 1992. Furthermore, video data which comprises sequences of images can be compressed by taking  
10 advantage of the similarities between successive images. Where a portion of successive images does not change from one image to the next, the portion of the first image can be used for the next image, thereby reducing the number of bits necessary to represent the sequence of images.

15 JPEG (Joint Photographics Experts Group) is an international standard for still-images which typically achieves about a 10:1 compression ratios for monochrome images and 15:1 compression ratios for color images. The JPEG standard employs a combination of a type of Fourier  
20 transform, known as the discrete-cosine transform, in combination with quantization and a Huffman-like code. MPEG1 (Motion Picture Experts Group) and MPEG2 are two international video compression standards. MPEG2 is a standard which is still evolving which is targeted for  
25 broadcast television. MPEG2 allows the picture quality to be adjusted to allow more television information to be transmitted, e.g., on a given coaxial cable. H.261 is another video standard based on the discrete-cosine transform. H.261 also varies the amount of compression  
30 depending on the data rate required.

Compression standards such as JPEG, MPEG1, MPEG2 and H.261 are optimized to minimize the signal to noise ratio of the error between the original and the reconstructed image. Due to this optimization, these methods are very  
35 complex. Chips implementing MPEG1, for example, may be costly and require as many as 1.5 million transistors. These methods only partially take advantage of the fact

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that the human visual system is quite insensitive to signal to noise ratio. Accordingly, some of the complexity inherent in these standards is wasted on the human eye. Moreover, because these standards encode by 5 areas of the image, they are not particularly sensitive to edge-type information which is of high importance to the human visual system. In view of these maladaptions of current compression standards to the characteristics of the human visual system, a new compression and 10 decompression method is sought which handles the above-described boundary problem and which takes advantage of the fact that the human visual system is more sensitive to edge information than signal to noise ratio so that the complexity and cost of implementing the method can be 15 reduced.

#### SUMMARY

A compression and decompression method using wavelet decomposition, frequency based tree encoding, tree based motion encoding, frequency weighted quantization, Huffman 20 encoding, and tree based activity estimation for bit rate control is disclosed. Forward and inverse quasi-perfect reconstruction transforms are used to generate the wavelet decomposition and to reconstruct data values close to the original data values. The forward and inverse quasi- 25 perfect reconstruction transforms utilize special filters at the boundaries of the data being transformed and/or inverse transformed to solve the above-mentioned boundary problem.

In accordance with some embodiments of the present 30 invention, a decompression method uses four coefficient inverse perfect reconstruction digital filters. The coefficients of these inverse perfect reconstruction digital filters require a small number of additions to implement thereby enabling rapid decompression in software 35 executing on a general purpose digital computer having a microprocessor. The method partially inverse transforms a

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sub-band decomposition to generate a small low frequency component image. This small image is expanded in one dimension by performing interpolation on the rows of the small image and is expanded in a second dimension by replicating rows of the interpolated small image. Transformed chrominance data values are inverse transformed using inverse perfect reconstruction digital filters having a fewer number of coefficients than the inverse perfect reconstruction digital filters used to inverse transform the corresponding transformed luminance data values. In one embodiment, two coefficient Haar digital filters are used as the inverse perfect reconstruction digital filters which inverse transform transformed chrominance data values. Variable-length tokens are used in the compressed data stream to indicate changes in encoding methods used to encode data values in the compressed data stream.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1-4 (Prior Art) are diagrams illustrating a sub-band decomposition of an image.

Figure 5 (Prior Art) is a diagram illustrating a boundary problem associated with the generation of prior art sub-band decompositions.

Figure 6 (Prior Art) is a diagram illustrating a solution to the boundary problem associated with the generation of prior art sub-band decompositions.

Figure 7 is a diagram illustrating a one-dimensional decomposition.

Figures 8 and 9 are diagrams illustrating the separation of an input signal into a high pass component and a low pass component.

Figures 10, 11, 14 and 15 are diagrams illustrating a transformation in accordance with one embodiment of the present invention.

Figures 12 and 13 are diagrams illustrating the operation of high pass and low pass forward transform

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digital filters in accordance with one embodiment of the present invention.

Figure 16 is a diagram of a two-dimensional matrix of original data values in accordance with one embodiment of the present invention.

Figure 17 is a diagram of the two-dimensional matrix of Figure 16 after one octave of forward transform in accordance with one embodiment of the present invention.

Figure 18 is a diagram of the two-dimensional matrix of Figure 16 after two octaves of forward transform in accordance with one embodiment of the present invention.

Figures 19 and 20 are diagrams illustrating a boundary problem solved in accordance with one embodiment of the present invention.

Figure 21 is a diagram illustrating the operation of boundary forward transform digital filters in accordance with one embodiment of the present invention.

Figure 22 is a diagram illustrating the operation of start and end inverse transform digital filters in accordance with one embodiment of the present invention.

Figure 23 is a diagram illustrating a one-dimensional tree structure in accordance one embodiment of the present invention.

Figure 24A-D are diagrams illustrating the recursive filtering of data values to generate a one-dimensional decomposition corresponding with the one-dimensional tree structure of Figure 23.

Figure 25 is a diagram of a two-dimensional tree structure of two-by-two blocks of data values in accordance with one embodiment of the present invention.

Figure 26 is a pictorial representation of the data values of the two-dimension tree structure of Figure 25.

Figures 27-29 are diagrams illustrating a method and apparatus for determining the addresses of data values of a tree structure in accordance with one embodiment of the present invention.

Figure 30 and 31 are diagrams illustrating a

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quantization of transformed data values in accordance with one embodiment of the present invention.

Figures 32 and 33 are diagrams illustrating the sensitivity of the human eye to spatial frequency.

5      Figures 34 is a diagram illustrating the distribution of high pass component data values in a four octave wavelet decomposition of the test image Lenna.

Figure 35 is a diagram illustrating the distribution of data values of the test image Lenna before wavelet  
10 transformation.

Figure 36 is a block diagram illustrating a video encoder and a video decoder in accordance with one embodiment of the present invention.

Figure 37 is a diagram illustrating modes of the  
15 video encoder and video decoder of Figure 36 and the corresponding token values.

Figure 38 is a diagram illustrating how various flags combine to generate a new mode when the inherited mode is send in accordance with one embodiment of the present  
20 invention.

Figures 39-40 are diagrams of a black box on a white background illustrating motion.

Figures 41-43 are one-dimensional tree structures corresponding to the motion of an edge illustrated in  
25 Figures 39-40.

Figure 44 is a diagram illustrating variable-length tokens in accordance with one embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

##### 30      QUASI-PERFECT RECONSTRUCTION FILTERS

The wavelet transform was introduced by Jean Morlet in 1984 to overcome problems encountered in analyzing geological signals. See "Cycle-octave and Related Transforms In Seismic Signal Analysis", Goupillaud,  
35 Grossman and Morlet, Geoexploration, vol. 23, 1984. Since then, the wavelet transform has been a new and exciting

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method of analyzing signals and has already been applied to a wide range of tasks such as quantum mechanics and signal processing. The wavelet transform has a number of advantages over more traditional Fourier techniques  
 5 principally used today in the analysis of signals. The wavelet transform and the high and low pass four coefficient quasi-perfect reconstruction filters of the present invention are therefore described by relating them to the windowed Fourier transform.

10 The windowed Fourier transform is the principle transform used today to analyze the spectral components of a signal. The Fourier transform decomposes a signal under analysis into a set of complex sinusoidal basis functions. The resulting Fourier series can be interpreted as the  
 15 frequency spectra of the signal. The continuous Fourier transform is defined as follows:

$$F(\omega) = \int_{-\infty}^{\infty} e^{-j\omega t} f(t) dt \quad (\text{equ. 1})$$

Where  $f(t)$  is the time domain signal under analysis and  $F(\omega)$  is the Fourier transform of the signal under  
 20 analysis. Although many applications require an estimate of the spectral content of an input signal, the above formula is impractical for most systems. In order to calculate the Fourier transform, the input signal  $f(t)$  must be defined for all values of time  $t$ , whereas in most  
 25 practical systems,  $f(t)$  is only defined over a finite range of time.

Several methods have therefore been devised to transform the finite input signal into an infinite signal so that the Fourier transform can be applied. The  
 30 windowed Fourier transform is one such solution. The windowed Fourier transform is defined as follows:

$$F_w(\omega, \tau) = \int_{-\infty}^{\infty} w(t-\tau) e^{-j\omega t} f(t) dt \quad (\text{equ. 2})$$

Where  $f(t)$  is the time domain signal under analysis,

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$F_w(\omega, \tau)$  is the windowed Fourier transform of the time domain signal under analysis, and  $w(t)$  is the windowing function. The windowing function is usually chosen to be zero outside an interval of finite length. Alternatively, as the spectral content of the input  $f(t)$  varies with time, the input signal can be examined by performing the transform at time  $\tau$  using a more local window function. In either case, the output transform is the convolution of the window function and the signal under analysis so that the spectra of the window itself is present in the transform results. Consequently, the windowing function is chosen to minimize this effect. Looking at this technique from another viewpoint, the basis functions of a windowed Fourier transform are not complex sinusoids but rather are windowed complex sinusoids. Dennis Gabor used a real Gaussian function in conjunction with sinusoids of varying frequencies to produce a complete set of basis functions (known as Gabor functions) with which to analyze a signal. For a locality given by the effective width of the Gaussian function, the sinusoidal frequency is varied such that the entire spectrum is covered.

The wavelet transform decomposes a signal into a set of basis functions that can be nearly local in both frequency and time. This is achieved by translating and dilating a function  $\psi(t)$  that has spatial and spectral locality to form a set of basis functions:

$$\sqrt{s}\psi(s(t-u)) \quad (\text{equ. 3})$$

wherein  $s$  and  $u$  are real numbers and are the variables of the transform. The function  $\psi(t)$  is called the wavelet.

The continuous wavelet transform of a signal under analysis is defined as follows:

$$W(s, u) = \sqrt{s} \int_{-\infty}^{\infty} \psi(s(t-u)) f(t) dt \quad (\text{equ. 4})$$

Where  $f(t)$  is the time domain signal under analysis,

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$W(s,u)$  is its wavelet transform,  $\psi$  is the wavelet,  $s$  is the positive dilation factor and  $u$  is the scaled translation distance. The spatial and spectral locality of the wavelet transform is dependent on the characteristics of the wavelet.

Because the signal under analysis in the compression of digitally sampled images has finite length, the discrete counterpart of the continuous wavelet transform is used. The wavelet transform performs a multiresolution decomposition based on a sequence of resolutions often referred to as "octaves". The frequencies of consecutive octaves vary uniformly on a logarithmic frequency scale. This logarithmic scale can be selected so that consecutive octaves differ by a factor of two in frequency. The basis functions are:

$$\{\psi^j(x-2^{-j}n)\} \text{ for } (j,n) \in \mathbb{Z}^2 \quad (\text{equ. 5})$$

where  $\mathbb{Z}$  is the set of all integers,  $\mathbb{Z}^2 = \{(j,n) : j,n \in \mathbb{Z}\}$ , and  $\psi^j(x) = \sqrt{2^j} \psi(2^j x)$ .

In a sampled system, a resolution  $r$  signifies that the signal under analysis has been sampled at  $r$  samples per unit length. A multiresolution analysis studies an input signal at a number of resolutions, which in the case of the present invention is the sequence  $r = 2^j$  where  $j \in \mathbb{Z}$ . The difference in frequency between consecutive octaves therefore varies by a factor of two.

Stephane Mallat formalized the relationship between wavelet transforms and multiresolution analysis by first defining a multiresolution space sequence  $\{V_j\}_{j \in \mathbb{Z}}$ , where  $V_j$  is the set of all possible approximated signals at resolution  $2^j$ . He then showed that an orthonormal basis for  $V_j$  can be constructed by  $\{\phi^j(x-2^{-j}n)\}_{n \in \mathbb{Z}}$ .  $\phi(x)$  is called the scaling function where for any  $j \in \mathbb{Z}$ ,  $\phi^j(x) = \sqrt{2^j} \phi(2^j x)$ . He then showed that a signal  $f(x)$  can be approximated at a resolution  $2^j$  by the set of samples:



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$$S_j = \{\sqrt{2^j} \langle f, \phi_n^j \rangle\}_{n \in \mathbb{Z}} \quad (\text{equ. 6})$$

where  $\langle f, g \rangle = \int_{-\infty}^{\infty} f(x)g(x)dx$ , where  $f, g \in L^2(\mathbb{R})$ ,  
 the set of square integrable functions on  $\mathbb{R}$ . This is  
 equivalent to convolving the signal  $f(x)$  with the scaling  
 5 function  $\phi(-x)$  at a sampling rate of  $2^j$ . However, this  
 representation is highly redundant because  $V_j \subset V_{j+1}, j \in \mathbb{Z}$ .  
 It would be more efficient to generate a sequence of  
 multiresolution detail signals  $O_j$  which represents the  
 difference information between successive resolutions  
 10  $O_j \oplus V_j = V_{j+1}$  where  $O_j$  is orthogonal to  $V_j$ . Mallat proved that  
 there exists a function  $\Psi(x)$  called the wavelet where:

$$\Psi^j(x) = \sqrt{2^j} \Psi(2^j x) \quad (\text{equ. 7})$$

such that  $\{\Psi(x-2^j n)\}_{n \in \mathbb{Z}}$  is an orthonormal basis of  $O_j$  and  
 $\{\Psi(x-2^j n)\}, (j, n) \in \mathbb{Z}^2$ , is an orthonormal basis of  $L^2(\mathbb{R})$ .  
 15 The detail signal at resolution  $2^{j+1}$  is represented by the  
 set of data values:

$$N_j = \{\sqrt{2^j} \langle f, \Psi_n^j \rangle\}_{n \in \mathbb{Z}} \quad (\text{equ. 8})$$

which is equivalent to convolving the signal  $f(x)$  with the  
 wavelet  $\Psi(-x)$  at a sampling rate of  $2^j$ .

20 Hence, the original signal  $f(x)$  can be completely  
 represented by the sets of data values  $(S_j, (N_j)_{J \leq j \leq -1})$ ,  
 where  $J < 0$  gives the number of octaves. This  
 representation in the form of data values is known as the  
 discrete wavelet decomposition. The  $S_j$  notation used by  
 25 Mallat refers to recursively low pass filter values of the  
 original signal.  $S_0$  corresponds to the original data  
 values  $D$ .  $S_1$  corresponds to the  $H$  data values from the  
 low pass filter.  $N_1$  corresponds to the  $G$  data values from  
 the high pass filter.  $S_j$  corresponds to the next low pass  
 30 filtered values from the previous  $H$  sub-band.  $N_j$   
 corresponds to the next high pass filtered values from the  
 previous  $H$  sub-band.

If the sampling patterns of the discrete windowed

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Fourier transform and the discrete wavelet transform are compared while maintaining the spatial locality of the highest frequency sample for both transforms, then the efficiency of the discrete wavelet decomposition is revealed. The window Fourier transform produces a linear sampling grid, each data value being a constant spatial distance or a constant frequency away from its neighbor. The result is a heavy over-sampling of the lower frequencies. The wavelet transform, in contrast, samples each of its octave wide frequency bands at the minimum rate such that no redundant information is introduced into the discrete wavelet decomposition. The wavelet transform is able to achieve highly local spatial sampling at high frequencies by the use of octave wide frequency bands. At low frequencies, spectral locality takes precedence over spatial locality.

Figure 7 illustrates the spatial and spectral locality of a sequence of sampled data values. The box surrounding a data value represents the spatial and spectral locality of the data value. The regions of Figure 7 are presented for explanation purposes. In reality there is some overlap and aliasing between adjacent data values, the characteristics of which are determined by the particular wavelet function used.

Mallat showed the wavelet transform can be computed with a pyramid technique, where only two filters are used. Using this technique,  $S_j$  and  $N_j$  are calculated from  $S_{j+1}$ ,  $S_j$  being used as the input for the next octave of decomposition. A low pass filter  $H$ :

$$h(n) = \frac{1}{\sqrt{2}} \langle \phi_0^{-1}, \phi_n^0 \rangle \quad (\text{equ. 9})$$

Mallat showed that  $S_j$  can be calculated by convolving from  $S_{j+1}$  with  $H$  and keeping every other output (i.e. sub-sampling by a factor of 2).

A method for calculating  $N_j$  from  $S_{j+1}$  can also be derived. This method involves convolving  $S_{j+1}$  with a high

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pass filter G and sub-sampling by a factor of 2. The high pass filter G is defined by the following coefficients:

$$g(n) = (-1)^{1-n} h(1-n) \quad (\text{equ. 10})$$

The relationship between the H and G filters results in a large saving when the filters are implemented in hardware.

Figures 8 and 9 illustrate that these two filters H and G form a complementary pair that split an input signal into two half band output signals. Both the high and the low pass outputs can be sub-sampled by a factor of two without corrupting the high frequency information because any aliasing introduced by the sub-sampling will be corrected in the reconstruction. There are the same number of filtered data values as there are original image data values.

The particular wavelet which is best in analyzing a signal under analysis is heavily dependent on the characteristics of the signal under analysis. The closer the wavelet resembles the features of the signal, the more efficient the wavelet representation of the signal will be. In addition, reconstruction errors introduced by quantization resemble the wavelet. Typically, the amount of aliasing varies with spatial support (the number of coefficients of the wavelet filters). Long wavelets can be constructed such that aliasing between adjacent octave bands is minimized. However, the spatial equivalent of aliasing, overlap, increases with filter length. Conversely, short wavelets have little or no overlap spatially but exhibit large amounts of aliasing in the frequency domain. To properly determine the suitability of a wavelet for a particular application, these factors of size and shape must be considered.

To apply the wavelet transform to image processing, the present invention employs a particular wavelet called the four coefficient Daubechies wavelet. Because the four

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coefficient Daubechies wavelet has only four coefficients, it is very short. This is well-suited for analyzing important image features such as object edges. Edges by definition are spatially local discontinuities. Edges often consist of a wide spectral range which, when filtered through a high pass filter, give rise to relatively larger filtered outputs only when the analysis filter coincides with the edge. When the analysis filter does not coincide with the edge, relatively smaller filtered outputs are output by the filter. The shorter the analysis filter used, the more finely the spatial position of the edge is resolved. Longer filters produce more of the relatively larger data values to represent an edge. The shortness of the filter also makes the transform calculation relatively inexpensive to implement compared with that of longer filters or image transformations such as the Fourier or discrete cosine transforms. The four coefficient Daubechies wavelet was selected for use only after a careful analysis of both its spatial and aliasing characteristics. Longer wavelets such as the six coefficient Daubechies wavelet could, however, also be used if a more complex implementation were acceptable. Short filters such as the two coefficients Haar wavelet could also be used if the attendant high levels of noise were acceptable.

The true coefficients of the four coefficient Daubechies wavelet are:

$$a = \frac{1+\sqrt{3}}{8}, b = \frac{3+\sqrt{3}}{8}, c = \frac{3-\sqrt{3}}{8}, d = \frac{-1+\sqrt{3}}{8} \quad (\text{equ. 11})$$

The low pass four coefficient Daubechies digital filter is given by:

$$H\left(\frac{x}{2}\right) = aD(x-1) + bD(x) + cD(x+1) - dD(x+2) \quad (\text{equ. 12})$$

The high pass four coefficient Daubechies digital filter is given by:

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$$G\left(\frac{x}{2}\right) = dD(x-1) + cD(x) - bD(x+1) + aD(x+2) \quad (\text{equ. 13})$$

In equations 12 and 13,  $D(x-1)$ ,  $D(x)$ ,  $D(x+1)$  and  $D(x+2)$  are four consecutive data values.  $H\left(\frac{x}{2}\right)$  and  $G\left(\frac{x}{2}\right)$  are true perfect reconstruction filters, i.e. the inverse transform  
 5 perfectly reconstructs the original data. For example, when the filters operate on data values  $D(1)$ ,  $D(2)$ ,  $D(3)$  and  $D(4)$ , outputs  $H(1)$  and  $G(1)$  are generated. Index  $x$  in this case would be 2. Due to the presence of the  $\frac{x}{2}$  as the index for the filters  $H$  and  $G$ , the values of  $x$  can  
 10 only be even integers.

To simplify the computational complexity involved in performing the transformation on real data, the coefficients of the four coefficient Daubechies filter which are non-rational numbers are converted into rational  
 15 numbers which can be efficiently implemented in software or hardware. Floating point coefficients are not used because performing floating point arithmetic is time consuming and expensive when implemented in software or hardware.

20 To convert the four Daubechies coefficients for implementation, three relationships of the coefficients  $a$ ,  $b$ ,  $c$  and  $d$  are important. In order for the  $H$  filter to have unity gain, the following equation must hold:

$$a + b + c - d = 1 \quad (\text{equ. 14})$$

25 In order for the  $G$  filter to reject all zero frequency components in the input data values, the following equation must hold:

$$a - b + c + d = 0 \quad (\text{equ. 15})$$

In order for the resulting  $H$  and  $G$  filters to be able to  
 30 generate a decomposition which is perfectly reconstructible into the original image data the following equation must hold:

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$$ac - bd = 0$$

(equ. 16)

True four coefficient Daubechies filters satisfy the above three equations 14, 15, and 16. However, when the coefficients of the true low and high pass four  
 5 coefficient Daubechies filters are converted for implementation, at least one of the three relationships must be broken. In the preferred embodiment, unity gain and the rejection of all zero frequency components are maintained. It is the third relationship of equation 16  
 10 that is compromised. Perfect reconstruction is compromised because the process of compressing image data itself inherently introduces some noise due to the tree coding and quantization of the present invention. The reconstructed data values therefore necessarily involve  
 15 noise when a real-world image is compressed and then reconstructed. We define filters which satisfy equations 14, and 15 and approximately satisfy equation 16, quasi-perfect reconstruction filters.

Table 2 illustrates a process of converting the  
 20 coefficients a, b, c and d for implementation.

$$a = \frac{1+\sqrt{3}}{8} = .3415(32) = 10.92 = \frac{11}{32}$$

$$b = \frac{3+\sqrt{3}}{8} = .5915(32) = 18.92 = \frac{19}{32}$$

$$c = \frac{3-\sqrt{3}}{8} = .1585(32) = 5.072 = \frac{5}{32}$$

$$25 \quad d = \frac{-1+\sqrt{3}}{8} = .0915(32) = 2.928 = \frac{3}{32}$$

Table 2

The true four coefficient Daubechies filter coefficients are listed in the left hand column of Table 2. In the next column to the right, the true coefficients are shown  
 30 rounded to four places beyond the decimal point. The

rounded coefficients are scaled by a factor of 32 to achieve the values in the next column to the right. From each value in the third column, an integer value is selected. Which integers are selected has a dramatic effect on the complexity of the software or hardware which compresses the image data. The selected integers are divided by 32 so that the scaling by 32 shown in the second column does not change the values of the resulting converted coefficients.

10 In selecting the integers for the fourth column, the relationship of the three equations 14, 15 and 16 are observed. In the case of  $a = 11/32$ ,  $b = 19/32$ ,  $c = 5/32$  and  $d = 3/32$ , the relationships  $a+b+c-d=1$  and  $a-b+c+d=0$  both are maintained. Because the converted coefficients  
15 in the rightmost column of Table 2 are quite close to the true coefficient values in the leftmost column, the resulting four coefficient filters based on coefficients  $a$ ,  $b$ ,  $c$  and  $d$  allow near perfect reconstruction. On a typical 640 by 480 image, the error between the original  
20 and reconstructed data values after forward and then inverse transformation has been experimentally verified to exceed 50 dB.

The resulting high pass four coefficient quasi-Daubechies filter is:

$$25 \quad H\left(\frac{x}{2}\right) = \frac{11}{32}D(x-1) + \frac{19}{32}D(x) + \frac{5}{32}D(x+1) - \frac{3}{32}D(x+2) \text{ (equ. 17)}$$

The resulting low pass four coefficient quasi-Daubechies filter is:

$$G\left(\frac{x}{2}\right) = \frac{3}{32}D(x-1) + \frac{5}{32}D(x) - \frac{19}{32}D(x+1) + \frac{11}{32}D(x+2) \text{ (equ. 18)}$$

Because the high and low pass four coefficient quasi-  
30 Daubechies filters satisfy equations 14 and 15 and approximately satisfy equation 16, the high and low pass four coefficient quasi-Daubechies filters are quasi-perfect reconstruction filters.

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Note that the particular converted coefficients of the quasi-Daubechies filters of equations 17 and 18 result in significant computational simplicity when implementation is either software and/or hardware.

5 Multiplications and divisions by factors of two such as multiplications and divisions by 32 are relatively simple to perform. In either hardware or software, a multiplication by 2 or a division by 2 can be realized by a shift. Because the data values being operated on by the  
10 digital filter already exist in storage when the filter is implemented in a typical system, the shifting of this data after the data has been read from storage requires little additional computational overhead. Similarly, changing the sign of a quantity involves little additional  
15 overhead. In contrast, multiplication and division by numbers that are not a power of 2 require significant overhead to implement in both software and hardware. The selection of the coefficients in equations 17 and 18 allows  $H(x)$  and  $G(x)$  to be calculated with only additions  
20 and shifts. In other words, all multiplications and divisions are performed without multiplying or dividing by a number which is not a power of 2. Due to the digital filter sequencing through the data values, pipelining techniques can also be employed to reduce the number of  
25 adds further by using the sums or differences computed when the filters were operating on prior data values.

Moreover, the magnitudes of the inverse transform filter coefficients are the same as those of the transform filter itself. As described further below, only the order  
30 and signs of the coefficients are changed. This reduces the effective number of multiplications which must be performed by a factor of two when the same hardware or software implementation is to be used for both the forward and inverse transform. The fact that the signal being  
35 analyzed is being sub-sampled reduces the number of additions by a factor of two because summations are required only on the reading of every other sample. The



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effective number of filters is therefore only one to both transform the data into the decomposition and to inverse transform the decomposition back into the image data.

#### IMAGE COMPRESSION AND DECOMPRESSION USING THE QUASI-PERFECT RECONSTRUCTION TRANSFORM

5 Color images can be decomposed by treating each Red-Green-Blue (or more usually each Luminance-Chrominance-Chrominance channel) as a separate image. In the case of Luminance-Chrominance-Chrominance (YUV or YIQ) images the  
10 chrominance components may already have been sub-sampled. It may be desirable therefore, to transform the chrominance channels through a different number of octaves than the luminance channel. The eye is less sensitive to chrominance at high spatial frequency and therefore these  
15 channels can be sub-sampled without loss of perceived quality in the output image. Typically these chrominance channels are sub-sampled by a factor of two in each dimension so that they together take only 50 percent of the bandwidth of the luminance channel. When implementing  
20 an image compression technique, the chrominance channels are usually treated the same way as the luminance channel. The compression technique is applied to the three channels independently. This approach is reasonable except in the special cases where very high compression ratios and very  
25 high quality output are required. To squeeze the last remaining bits from a compression technique or to achieve more exacting quality criteria, knowledge of how the chrominance rather than luminance values are perceived by the human visual system can be applied to improve the  
30 performance of the compression technique by better matching it with the human visual system.

Figure 10 is an illustration of a two dimensional matrix of data values. There are rows of data values extending in the horizontal dimension and there are  
35 columns of data values extending in the vertical dimension. Each of the data values may, for example, be

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an 8-bit binary number of image pixel information such as the luminance value of a pixel. The data values of Figure 10 represent an image of a black box 100 on a white background 101.

5 To transform the data values of the image of Figure 10 in accordance with one aspect of the present invention, a high pass four coefficient quasi-Daubechies digital filter is run across the data values horizontally, row by row, to result in a block 102 of high pass output values G  
10 shown in Figure 11. The width of the block 102 of high pass output values in Figure 11 is half the width of the original matrix of data values in Figure 10 because the high pass four coefficient quasi-Daubechies digital filter is moved across the rows of the data values by twos.  
15 Because only one additional digital filter output is generated for each additional two data values processed by the digital filter, the data values of Figure 10 are said to have been sub-sampled by a factor of two.

Figure 12 illustrates the sub-sampling performed by  
20 the high pass digital filter. High pass output  $G_1$  is generated by the high pass digital filter from data values  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$ . The next high pass output generated, output  $G_2$ , is generated by the high pass digital filter from data values  $D_3$ ,  $D_4$ ,  $D_5$  and  $D_6$ . The high pass digital  
25 filter therefore moves two data values to the right for each additional high pass output generated.

A low pass four coefficient quasi-Daubechies digital filter is also run across the data values horizontally, row by row, to generate H block 103 of the low pass  
30 outputs shown in Figure 11. This block 103 is generated by sub-sampling the data values of Figure 10 in the same way the block 102 was generated. The H and G notation for the low and high pass filter outputs respectively is used as opposed to the  $S_j$  and  $O_j$  notation used by Mallat to  
35 simplify the description of the two-dimensional wavelet transform.

Figure 13 illustrates the sub-sampling of the low

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pass digital filter. Low pass output  $H_1$  is generated by the low pass digital filter from data values  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$ . The next low pass output generated, output  $H_2$ , is generated by the low pass digital filter from data values  $D_3$ ,  $D_4$ ,  $D_5$  and  $D_6$ . The low pass digital filter therefore moves two data values to the right for each additional low pass output generated.

After the high and low pass four coefficient quasi-Daubechies digital filters have generated blocks 102 and 103, the high and low pass four coefficient quasi-Daubechies digital filters are run down the columns of blocks 102 and 103. The values in blocks 102 and 103 are therefore sub-sampled again. The high pass four coefficient quasi-Daubechies digital filter generates blocks 104 and 105. The low pass four coefficient quasi-Daubechies digital filter generates blocks 106 and 107. The resulting four blocks 104-107 are shown in Figure 14. Block 106 is the low frequency component of the original image data. Blocks 107, 104 and 105 comprise the high frequency component of the original image data. Block 106 is denoted block HH. Block 107 is denoted block GH. Block 104 is denoted block HG. Block 105 is denoted block GG.

This process of running the high and low pass four coefficient quasi-Daubechies digital filters across data values both horizontally and vertically to decompose data values into high and low frequency components is then repeated using the data values of the HH block 106 as input data values. The result is shown in Figure 15. Block 108 is the low frequency component and is denoted block HHHH. Blocks 109, 110 and 111 comprise octave 1 of the high frequency component and are denoted HHHG, HHGH, HHGG, respectively. Blocks HG, GH and GG comprise octave 0 of the high frequency component.

Although this recursive decomposition process is only repeated twice to produce high pass component octaves 0 and 1 in the example illustrated in connection with

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Figures 10-15, other numbers of recursive decomposition steps are possible. Recursively decomposing the original data values into octaves 0, 1, 2 and 3 has been found to result in satisfactory results for most still image data 5 and recursively decomposing the original data into octaves 0, 1, and 2 has been found to result in satisfactory results for most video image data.

Moreover, the horizontal and subsequent vertical operation of the high and low pass filters can also be 10 reversed. The horizontal and subsequent vertical sequence is explained in connection with this example merely for instructional purposes. The filters can be moved in the vertical direction and then in the horizontal direction. Alternatively, other sequences and dimensions of moving 15 the digital filters through the data values to be processed is possible.

It is also to be understood that if the original image data values are initially arrayed in a two dimensional block as shown in Figure 10, then the 20 processing of the original image data values by the high and low pass filters would not necessarily result in the HH values being located all in an upper right hand quadrant as is shown in Figure 14. To the contrary, depending on where the generated HH values are written, 25 the HH data values can be spread throughout a block. The locations of the HH values are, however, determinable. The HH values are merely illustrated in Figure 14 as being located all in the upper lefthand quadrant for ease of illustration and explanation.

30 Figure 16 is an illustration showing one possible twelve-by-twelve organization of original image data values in a two dimensional array. Figure 16 corresponds with Figure 10. The location in the array of each data value is determined by a row number and column number. A 35 row number and column number of a data value may, for example, correspond with a row address and column address in an addressed storage medium. This addressed storage

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medium may, for example, be a semiconductor memory, a magnetic storage medium, or an optical storage medium. The row and column may, for example, also correspond with a pixel location including a location of a pixel on a cathode-ray tube or on a flat panel display.

Figure 17 is an illustration showing the state of the two dimensional array after a one octave decomposition. The HH low frequency components are dispersed throughout the two dimensional array as are the HG values, the GH values, and the GG values. The subscripts attached to the various data values in Figure 17 denote the row and column location of the particular data value as represented in the arrangement illustrated in Figure 14.  $HH_{00}$ ,  $HH_{01}$ ,  $HH_{02}$ ,  $HH_{03}$ ,  $HH_{04}$  and  $HH_{05}$ , for example, are six data values which correspond with the top row of data values in HH block 106 of Figure 14.  $HH_{00}$ ,  $HH_{10}$ ,  $HH_{20}$ ,  $HH_{30}$ ,  $HH_{40}$  and  $HH_{50}$ , for example, are six data values which correspond with the leftmost column of data values in HH block 106 of Figure 14.

When the high and the low pass forward transform digital filters operate on the four data values  $D_{01}$ ,  $D_{02}$ ,  $D_{03}$  and  $D_{04}$  of Figure 16, the output of the low pass forward transform digital filter is written to location row 0 column 2 and the output of the high pass forward transform digital filter is written to location row 0 column 3. Next, the high and low pass forward transform digital filters are moved two locations to the right to operate on the data values  $D_{05}$ ,  $D_{06}$ ,  $D_{07}$  and  $D_{08}$ . The outputs of the low and high pass forward transform digital filters are written to locations row 0 column 4 and row 0 column 5, respectively. Accordingly, the outputs of the low and high frequency forward transform digital filters are output from the filters to form an interleaved sequence of low and high frequency component data values which overwrite the rows of data values in the two dimensional array.

Similarly, when the low and high pass forward

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transform digital filters operate on the four data values at locations column 0, rows 1 through 4, the output of the low pass forward transform digital filter is written to location column 0 row 2. The output of the high pass forward transform digital filter is written to location column 0 row 3. Next the low and high pass forward transform digital filters are moved two locations downward to operate on the data values at locations column 0, rows 3 through 6. The outputs of the low and high pass forward transform digital filters are written to locations column 0 row 4 and column 0 row 5, respectively. Again, the outputs of the low and high pass forward transform digital filters are output from the filters in an interleaved fashion to overwrite the columns of the two dimensional array.

Figure 18 is an illustration showing the state of the two dimensional array after a second octave decomposition. The HHHH low frequency components corresponding which block 108 of Figure 15 as well as the octave 1 high frequency components HHGH, HHMG and HHGG are dispersed throughout the two dimensional array. When the HH values  $HH_{01}$ ,  $HH_{02}$ ,  $HH_{03}$  and  $HH_{04}$  of Figure 17 are processed by the low and high pass forward transform digital filters, the outputs are written to locations row 0 column 4 and row 0 column 6, respectively. Similarly, when the values at locations column 0, rows 2, 4, 6 and 8 are processed by the low and high pass forward transform digital filters, the results are written to locations column 0 row 4 and column 0 row 6, respectively. The data values in Figure 18 are referred to as transformed data values. The transformed data values are said to comprise the decomposition of the original image values.

This method of reading data values, transforming the data values, and writing back the output of the filters is easily expanded to a two dimensional array of a very large size. Only a relatively small number of locations is shown in the two dimensional array of Figures 10-18 for

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ease of explanation and clarity of illustration.

The transformed data values are reconverted back into image data values substantially equal to the original image data by carrying out a reverse process. This reverse process is called the inverse transform. Due to the interleaved nature of the decomposition data in Figure 18, the two digital filters used to perform the inverse transform are called interleaved inverse transform digital filters. Odd data values are determined by an odd interleaved inverse digital filter O. Even data values are determined by the even interleaved inverse transform digital filter E.

The odd and even interleaved inverse digital filters can be determined from the low and high pass forward transform digital filters used in the forward transform because the coefficients of the odd interleaved inverse transform digital filters are related to the coefficients of the low and high pass forward transform filters. To determine the coefficients of the odd and even interleaved inverse transform digital filters, the coefficients of the low and high pass forward transform digital filters are reversed. Where the first, second, third and fourth coefficients of the low pass forward transform digital filter H of equation 17 are denoted a, b, c and -d, the first, second, third and fourth coefficients of a reversed filter H\* are denoted -d, c, b and a. Similarly, where the first, second, third and fourth coefficients of the high pass forward transform digital filter G of equation 18 are denoted d, c, -b and a, the first, second, third and fourth coefficients of a reverse filter G\* are denoted a, -b, c and d.

The first through the fourth coefficients of the even interleaved inverse transform digital filter E are the first coefficient of H\*, the first coefficient of G\*, the third coefficient of H\*, and the third coefficient of G\*. The coefficients of the even interleaved inverse transform digital filter E therefore are -d, a, b and c. In the

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case of the low and high pass four coefficient quasi-Daubechies filters used in the transform where  $a = \frac{11}{32}$ ,  $b = \frac{19}{32}$ ,  $c = \frac{5}{32}$  and  $d = \frac{3}{32}$ , the even interleaved inverse transform digital filter is:

$$5 \quad \frac{D(2x)}{2} = -\frac{3}{32}H(x-1) + \frac{11}{32}G(x-1) + \frac{19}{32}H(x) + \frac{5}{32}G(x) \quad (\text{equ. 19})$$

where  $H(x-1)$ ,  $G(x-1)$ ,  $H(x)$  and  $G(x)$  are transformed data values of a decomposition to be inverse transformed.

The first through the fourth coefficients of the odd interleaved inverse transform digital filter 0 are the  
 10 second coefficient of  $H^*$ , the second coefficient of  $G^*$ , the fourth coefficient of  $H^*$ , and the fourth coefficient of  $G^*$ . The coefficients of the odd interleaved inverse transform digital filter 0 therefore are  $c$ ,  $-b$ ,  $a$  and  $d$ . In the case of the low and high pass four coefficient  
 15 quasi-Daubechies filters used in the transform where  $a = \frac{11}{32}$ ,  $b = \frac{19}{32}$ ,  $c = \frac{5}{32}$  and  $d = \frac{3}{32}$ , the odd interleaved inverse transform digital filter is:

$$\frac{D(2x-1)}{2} = \frac{5}{32}H(x-1) - \frac{19}{32}G(x-1) + \frac{11}{32}H(x) + \frac{3}{32}G(x) \quad (\text{equ. 20})$$

where  $H(x-1)$ ,  $G(x-1)$ ,  $H(x)$  and  $G(x)$  are data values of a  
 20 decomposition to be inverse transformed.

To inverse transform the transformed data values of Figure 18 into the data values of Figure 17, the HHHG, HHGG, HHGH and data values are inverse transformed with the HHHH data values to create the HH data values of  
 25 Figure 17. This process corresponds with the inverse transformation of HHHG block 109, HHGH block 110, HHGG block 111, and HHHH block 108 of Figure 15 back into the HH data values of block 106 of Figure 14. The HG, GH and GG data values of Figure 18 are therefore not processed by  
 30 the odd and even interleaved inverse transform digital filters in this step of the inverse transform.



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In Figure 18, the odd interleaved inverse transform digital filter processes the values in locations column 0, rows 0, 2, 4 and 6 to generate the odd data value at location column 0 row 2. The even interleaved inverse transform digital filter data also processes the values in the same locations to generate the even data value at location column 0 row 4. The odd and even interleaved inverse transform digital filters then process the values in locations column 0, rows 4, 6, 8 and A to generate the values at locations column 0 row 6 and column 0 row 8, respectively. Each of the six columns 0, 2, 6, 4, 8, and A of the values of Figure 18 are processed by the odd and even interleaved inverse transform digital filters in accordance with this process.

15 The various locations are then processed again by the odd and even interleaved inverse transform digital filters, this time in the horizontal direction. The odd and even interleaved inverse transform digital filters process the values at locations row 0 columns 0, 2, 4 and 20 6 to generate the values at locations row 0 column 2 and row 0 column 4, respectively. The odd and even interleaved inverse transform digital filters process the values at locations row 0 columns 4, 6, 8 and A to generate the values at locations row 0 column 6 and 25 row 0 column 8, respectively. Each of the six rows 0, 2, 4 and 8 and of values are processed by the even and odd interleaved inverse transform digital filters in accordance with this process. The result is the reconstruction shown in Figure 17.

30 The even and odd interleaved inverse transform digital filters then process the values shown in Figure 17 into the data values shown in Figure 16. This inverse transformation corresponds with the transformation of the HH block 106, the HG block 104, the GH block 107 and the GG 35 block 105 of Figure 14 into the single block of data value of Figure 10. The resulting reconstructed data values of Figure 16 are substantially equal to the original image

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data values.

Note, however, that in the forward transform of the data values of Figure 16 into the data values of Figure 17 that the low and high pass four coefficient quasi-  
5 Daubechies digital filters cannot generate all the data values of Figure 17 due to the digital filters requiring data values which are not in the twelve by twelve matrix of data values of Figure 16. These additional data values are said to be beyond the "boundary" of the data values to  
10 be transformed.

Figure 19 illustrates the high pass four coefficient quasi-Daubechies digital filter operating over the boundary to generate the  $G_0$  data value. In order to generate the  $G_0$  data value in the same fashion that the  
15 other high frequency G data values are generated, the high pass digital filter would require data values  $D_{-1}$ ,  $D_0$ ,  $D_1$  and  $D_2$  as inputs. Data value  $D_{-1}$ , however, does not exist. Similarly, Figure 20 illustrates the low pass four coefficient quasi-Daubechies digital filter operating over  
20 the boundary to generate the  $H_0$  data value. In order to generate the  $H_0$  data value in the same fashion that the other low frequency H data values are generated, the low pass digital filter would require data values  $D_{-1}$ ,  $D_0$ ,  $D_1$  and  $D_2$  as inputs. Data value  $D_{-1}$ , however, does not exist.

25 The present invention solves this boundary problem by using additional quasi-Daubechies digital filters to generate the data values adjacent the boundary that would otherwise require the use of data values outside the boundary. There is a high pass "start" quasi-Daubechies  
30 forward transform digital filter  $G_s$ , which is used to generate the first high pass output  $G_0$ . There is a low pass "start" quasi-Daubechies forward transform digital filter  $H_s$ , which is used to generate the first low pass output  $H_0$ . These start quasi-Daubechies forward transform  
35 digital filters are three coefficient filters rather than four coefficient filters and therefore require only three data values in order to generate an output. This allows

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the start quasi-Daubechies forward transform digital filters to operate at the boundary and to generate the first forward transform data values without extending over the boundary.

5        Figure 21 illustrates the low and high pass start quasi-Daubechies forward transform digital filters operating at the starting boundary of image data values  $D_0$  through  $D_9$ . The three coefficient low and high pass start quasi-Daubechies forward transform digital filters operate  
10 on data values  $D_0$ ,  $D_1$  and  $D_2$  to generate outputs  $H_0$  and  $G_0$ , respectively.  $H_1$ ,  $H_2$ ,  $H_3$  and  $H_4$ , on the other hand, are generated by the low pass four coefficient quasi-Daubechies forward transform digital filter and  $G_1$ ,  $G_2$ ,  $G_3$  and  $G_4$  are generated by the high pass four coefficient  
15 quasi-Daubechies forward transform digital filter.

A similar boundary problem is encountered at the end of the data values such as at the end of the data values of a row or a column of a two-dimensional array. If the low and high pass four coefficient quasi-Daubechies  
20 filters G and H are used at the boundary in the same fashion that they are in the middle of the data values, then the four coefficient quasi-Daubechies forward transform digital filters would have to extend over the end boundary to generate the last low and high pass  
25 outputs, respectively.

The present invention solves this boundary problem by using additional quasi-Daubechies forward transform digital filters in order to generate the transformed data values adjacent the end boundary that would otherwise  
30 require the use of data outside the boundary. There is a low pass "end" quasi-Daubechies forward transform digital filter  $H_e$  which is used to generate the last low pass output. There is a high pass "end" quasi-Daubechies forward transform digital filter  $G_e$  which is used to  
35 generate the last high pass output. These two end quasi-Daubechies forward transform digital filters are three coefficient filters rather than four coefficient filters

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and therefore require only three data values in order to generate an output. This allows the end quasi-Daubechies forward transform digital filters to operate at the boundary and to generate the last transform data values without extending over the boundary.

Figure 21 illustrates two low and high pass end quasi-Daubechies forward transform digital filters operating at the end boundary of the image data. These three coefficient low and high pass end quasi-Daubechies forward transform digital filters operate on data values  $D_0$ ,  $D_A$  and  $D_B$  to generate outputs  $H_i$  and  $G_i$ , respectively. This process of using the appropriate start or end low or high pass filter is used in performing the transformation at the beginning and at the end of each row and column of the data values to be transformed.

The form of the low pass start quasi-Daubechies forward transform digital filter  $H_i$  is determined by selecting a value of a hypothetical data value  $D_1$  which would be outside the boundary and then determining the value of the four coefficient low pass quasi-Daubechies forward transform filter if that four coefficient forward transform filter were to extend beyond the boundary to the hypothetical data value in such a way as would be necessary to generate the first low pass output  $H_0$ . This hypothetical data value  $D_1$  outside the boundary can be chosen to have one of multiple different values. In some embodiments, the hypothetical data value  $D_1$  has a value equal to the data value  $D_0$  at the boundary. In some embodiments, the hypothetical data value  $D_1$  is set to zero regardless of the data value  $D_0$ . The three coefficient low pass start quasi-Daubechies forward transform digital filter  $H_i$  therefore has the form:

$$H_0 = K1 + bD_0 + cD_1 - dD_2 \quad (\text{equ. 21})$$

where  $K1$  is equal to the product  $aD_1$ , where  $D_0$  is the first data value at the start boundary at the start of a

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sequence of data values, and where a, b, c and d are the four coefficients of the four coefficient low pass quasi-Daubechies forward transform digital filter. If, for example, hypothetical data value  $D_1$  is chosen to be equal to the data value  $D_0$  adjacent but within the boundary, then  $K1=aD_0$  where  $a = 11/32$  and  $D_0$  is the data value adjacent the boundary, equation 21 then becomes:

$$H_0 = (a+b)D_0 + cD_1 - dD_2 \quad (\text{equ. 22})$$

The form of the high pass start quasi-Daubechies forward transform digital filter  $G_1$  is determined by the same process using the same hypothetical data value  $D_1$ . The high pass start quasi-Daubechies forward transform digital filter  $G_1$  therefore has the form:

$$G_0 = K2 + cD_0 - bD_1 + aD_2 \quad (\text{equ. 23})$$

where  $K2$  is equal to the product  $dD_1$ , where  $D_0$  is the first data value at the boundary at the start of a sequence of data values, and where a, b, c and d are the four coefficients of the four coefficient high pass quasi-Daubechies forward transform digital filter. If hypothetical data value  $D_1$  is chosen to be equal to  $D_0$ , then equation 23 becomes:

$$G_0 = (d + c)D_0 - bD_1 + aD_2 \quad (\text{equ. 24})$$

The form of the low pass end quasi-Daubechies forward transform digital filter  $H_1$  is determined in a similar way to the way the low pass start quasi-Daubechies forward transform digital filter is determined. A value of a data value  $D_c$  is selected which would be outside the boundary. The value of the four coefficient low pass quasi-Daubechies forward transform digital filter is then determined as if that four coefficient filter were to extend beyond the boundary to data value  $D_c$  in such a way

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as to generate the last low pass output  $H_j$ . The three coefficient low pass end quasi-Daubechies forward transform digital filter therefore has the form:

$$H_j = aD_j + bD_A + cD_B - K3 \quad (\text{equ. 25})$$

5 where  $K3$  is equal to the product  $dD_C$ , where  $D_B$  is the last data value of a sequence of data values to be transformed, and where  $a$ ,  $b$ ,  $c$  and  $d$  are the four coefficients of the four coefficient low pass quasi-Daubechies filter.  $D_B$  is the last data value in the particular sequence of data  
10 values of this example and is adjacent the end boundary. In the case where the hypothetical data value  $D_C$  is chosen to be equal to the data value  $D_B$  adjacent but within the end boundary, then  $K3=dD_B$  and equation 25 becomes:

$$H_j = aD_j + bD_A + (c-d)D_B \quad (\text{equ. 26})$$

15 The form of the high pass end quasi-Daubechies forward transform digital filter  $G_j$  is determined by the same process using the same data value  $D_C$ . The three coefficient high pass end quasi-Daubechies forward transform digital filter therefore has the form:

$$20 \quad G_j = dD_j + cD_A - bD_B + K4 \quad (\text{equ. 27})$$

where  $K4$  is equal to the product  $aD_C$ , where  $D_B$  is the last data value in this particular sequence of data values to be transformed, and where  $a$ ,  $b$ ,  $c$  and  $d$  are the four coefficients of the four coefficient high pass quasi-  
25 Daubechies forward transform digital filter.  $D_B$  is adjacent the end boundary. If hypothetical data value  $D_C$  is chosen to be equal to  $D_B$ , then equation 27 becomes:

$$G_j = dD_j + cD_A + (-b+a)D_B \quad (\text{equ. 28})$$

It is to be understood that the specific low and high

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pass end quasi-Daubechies forward transform digital filters are given above for the case of data values  $D_0$  through  $D_B$  of Figure 21 and are presented merely to illustrate one way in which the start and end digital filters may be determined. In the event quasi-Daubechies filters are not used for the low and high pass forward transform digital filters, the same process of selecting a hypothetical data value or values outside the boundary and then determining the value of a filter as if the filter were to extend beyond the boundary can be used. In some embodiments, multiple hypothetical data values may be selected which would all be required by the digital filters operating on the inside area of the data values in order to produce an output at the boundary. This boundary technique is therefore extendable to various types of digital filters and to digital filters having numbers of coefficients other than four.

As revealed by Figure 22, not only does the forward transformation of data values at the boundary involve a boundary problem, but the inverse transformation of the transformed data values back into original image data values also involves a boundary problem. In the present example where four coefficient quasi-Daubechies filters are used to forward transform non-boundary data values, the inverse transform involves an odd inverse transform digital filter as well as an even inverse transform digital filter. Each of the odd and even filters has four coefficients. The even and odd reconstruction filters alternately generate a sequence of inverse transformed data values.

In Figure 22, the data values to be transformed are denoted  $H_0, G_0 \dots H_4, G_4, H_5, G_5$ . Where the forward transform processes the rows first and then the columns, the inverse transform processes the columns first and then the rows. Figure 22 therefore shows a column of transferred data values being processed in a first step of the inverse transform. Both the forward and the inverse

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transforms in the described example, however, process the columns in a downward direction and process the rows in a left-right direction.

In Figure 22, the inverse transformed data values 5 reconstructed by the inverse transform digital filters are denoted  $D_0, D_1, D_2, D_3 \dots D_B$ . The odd inverse transform digital filter outputs are shown on the left and the even inverse transform digital filter outputs are shown on the right.

10 At the beginning of the sequence of data values  $H_0, G_0, H_1, G_1 \dots H_3$  and  $G_3$  to be inverse transformed, the four coefficient odd and even inverse transform digital filters determine the values of reconstructed data values  $D_1$  and  $D_2$  using values  $H_0, G_0, H_1$  and  $G_1$ , respectively. Reconstructed  
15 data value  $D_0$ , however, cannot be reconstructed from the four coefficient even inverse transform digital filter without the four coefficient even inverse transform digital filter extending beyond the boundary. If the four coefficient even inverse transform filter were to be  
20 shifted two data values upward so that it could generate data value  $D_0$ , then the even four coefficient inverse transform digital filter would require two additional data values to be transformed, data values  $G_{-1}$  and  $H_{-1}$ .  $H_0$  is, however, the first data value within the boundary and is  
25 located adjacent the boundary.

To avoid the even four coefficient inverse transform digital filter extending beyond the boundary, a two coefficient inverse transform digital filter is used:

$$D_0 = 4[(b-a)H_0 + (c-d)G_0] \quad (\text{equ. 29})$$

30 in the case where  $K1 = aD_0$  and  $K2 = dD_0$ .  $D_0$  is the first data value and  $H_0$  is the data value to be inverse transformed adjacent the start boundary. This even start inverse transform digital filter has the form of the four coefficient even inverse transform digital filter except  
35 that the  $G_{-1}$  data value outside the boundary is chosen to



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be equal to  $H_0$ , and the  $H_1$  data value outside the boundary is chosen to be equal to  $G_0$ . The even start inverse transform digital filter therefore determines  $D_0$  as a function of only  $H_0$  and  $G_0$  rather than as a function of  $H_1$ ,  $G_1$ ,  $H_0$  and  $G_0$ .

Similarly, a two coefficient odd end inverse transform digital filter is used to avoid the four coefficient odd inverse transform digital filter from extending beyond the end boundary at the other boundary of a sequence of data values to be inverse transformed. The two coefficient odd end inverse transform digital filter used is:

$$D_8 = 4[(c+d)H_7 - (a+b)G_7] \quad (\text{equ. 30})$$

in the case where  $K4 = aD_8$  and  $K3 = dD_8$ .  $D_8$  is the data value to be determined and  $G_7$  is the data value to be inverse transformed adjacent the end boundary. This odd end inverse transform digital filter has the form of the four coefficient odd inverse transform digital filter except that the  $H_8$  data value outside the boundary is chosen to be equal to  $G_7$  and the  $G_8$  data value outside the boundary is chosen to be equal to  $H_7$ . The odd end inverse transform digital filter therefore determines  $D_8$  as a function of only  $H_7$  and  $G_7$  rather than as a function of  $H_7$ ,  $G_7$ ,  $H_8$  and  $G_8$ .

It is to be understood that the particular even start and odd end inverse transform digital filters used in this embodiment are presented for illustrative purposes only. Where there is a different number of data values to be inverse transformed in a sequence of data values, an even end inverse transform digital filter may be used at the boundary rather than the odd end inverse transform digital filter. The even end inverse transform digital filter is an even inverse transform digital filter modified in accordance with the above process to have fewer coefficients than the even inverse transform digital

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filter operating on the inner data values. Where filters other than quasi-Daubechies inverse transform digital filters are used, start and end inverse transform digital filters can be generated from the actual even and odd  
 5 inverse transform digital filters used to inverse transform data values which are not adjacent to a boundary. In the inverse transform, the start inverse transform digital filter processes the start of the transformed data values at the start boundary, then the  
 10 four coefficient inverse transform digital filters process the non-boundary transformed data values, and then the end inverse transform digital filter processes the end of the transformed data values.

The true Daubechies filter coefficients a, b, c and d  
 15 fulfil some simple relationships which show that the inverse transform digital filters correctly reconstruct non-boundary original image data values.

$$a+c = \frac{1}{2}, b-d = \frac{1}{2}, c+d = \frac{1}{4}, b-a = \frac{1}{4} \quad (\text{equ. 31})$$

and the second order equations:

$$20 \quad ac-bd = 0, a^2+b^2+c^2+d^2 = \frac{1}{2} \quad (\text{equ. 32})$$

Take two consecutive H,G pairs:

$$H\left(\frac{x}{2}\right) = aD(x-1)+bD(x)+cD(x+1)-dD(x+2) \quad (\text{equ. 33})$$

$$G\left(\frac{x}{2}\right) = dD(x-1)+cD(x)-bD(x+1)+aD(x+2) \quad (\text{equ. 34})$$

$$H\left(\frac{x}{2}+1\right) = aD(x+1)+bD(x+2)+cD(x+3)-dD(x+4) \quad (\text{equ. 35})$$

$$25 \quad G\left(\frac{x}{2}+1\right) = dD(x+1)+cD(x+2)-bD(x+3)+aD(x+4) \quad (\text{equ. 36})$$

Multiplying Equations 33 to 36 using the inverse transform digital filters gives:

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$$cH\left(\frac{x}{2}\right) = acD(x-1) + bcD(x) + c^2D(x+1) - cdD(x+2) \quad (\text{equ. 37})$$

$$-bG\left(\frac{x}{2}\right) = -bdD(x-1) - bcD(x) + b^2D(x+1) - abD(x+2) \quad (\text{equ. 38})$$

$$aH\left(\frac{x}{2}+1\right) = a^2D(x+1) + abD(x+2) + acD(x+3) - adD(x+4) \quad (\text{equ. 39})$$

$$dG\left(\frac{x}{2}+1\right) = d^2D(x+1) + cdD(x+2) - bdD(x+3) + adD(x+4) \quad (\text{equ. 40})$$

$$5 \quad -dH\left(\frac{x}{2}\right) = -adD(x-1) - bdD(x) - cdD(x+1) + d^2D(x+2) \quad (\text{equ. 41})$$

$$aG\left(\frac{x}{2}\right) = adD(x-1) + acD(x) - abD(x+1) + a^2D(x+2) \quad (\text{equ. 42})$$

$$bH\left(\frac{x}{2}+1\right) = abD(x+1) + b^2D(x+2) + bcD(x+3) - bdD(x+4) \quad (\text{equ. 43})$$

$$cG\left(\frac{x}{2}+1\right) = cdD(x+1) + c^2D(x+2) - bcD(x+3) + acD(x+4) \quad (\text{equ. 44})$$

Summing equations 37-40 and 41-44 yields:

$$10 \quad cH\left(\frac{x}{2}\right) - bG\left(\frac{x}{2}\right) + aH\left(\frac{x}{2}+1\right) + dG\left(\frac{x}{2}+1\right) = \\ (ac-bd)D(x-1) + (a^2+b^2+c^2+d^2)D(x+1) + (ac-bd)D(x+3) = D(x+1)/2 \quad (\text{equ. 45})$$

$$15 \quad -dH\left(\frac{x}{2}\right) + aG\left(\frac{x}{2}\right) + bH\left(\frac{x}{2}+1\right) + cG\left(\frac{x}{2}+1\right) = \\ (ac-bd)D(x) + (a^2+b^2+c^2+d^2)D(x+2) + (ac-bd)D(x+4) = D(x+2)/2 \quad (\text{equ. 46})$$

Using the coefficients of the four coefficient true Daubechies filter, the relationships of equations 31 and 32 hold. Equations 45 and 46 therefore show that with a one bit shift at the output, the original sequence of data 20 values is reconstructed.

Similarly, that the even start reconstruction filter of equation 29 and the odd end reconstruction filter of equation 30 correctly reconstruct the original image data adjacent the boundaries is shown as follows.

25 For the even start filter, with the choice of  $K1 = aD_0$  and  $K2 = dD_0$  in equations 29 and 30, we have:

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$$H_0 = (a+b)D_0 + cD_1 - dD_2 \quad (\text{equ. 47})$$

$$G_0 = (c+d)D_0 - bD_1 + aD_2 \quad (\text{equ. 48})$$

so

$$bH_0 = b(a+b)D_0 + cbD_1 - dbD_2 \quad (\text{equ. 49})$$

$$5 \quad cG_0 = c(c+d)D_0 - cbD_1 + acD_2 \quad (\text{equ. 50})$$

$$aH_0 = a(a+b)D_0 + acD_1 - adD_2 \quad (\text{equ. 51})$$

$$dG_0 = d(c+d)D_0 - dbD_1 + adD_2 \quad (\text{equ. 51'})$$

and hence: from equation 29:

$$bH_0 + cG_0 - aH_0 - dG_0 = (b^2 - a^2 + c^2 - d^2)D_0 = \frac{D_0}{4} \quad (\text{equ. 52})$$

10 For the odd end filter, with the choice of  $K_1 = dD_B$   
and  $K_4 = aD_B$ , we have:

$$H_1 = aD_0 + bD_A + (c-d)D_B \quad (\text{equ. 53})$$

$$G_1 = dD_0 + cD_A + (a-b)D_B \quad (\text{equ. 54})$$

$$cH_1 = acD_0 + bcD_A + c(c-d)D_B \quad (\text{equ. 55})$$

$$15 \quad -bG_1 = -bdD_0 - bcD_A - b(a-b)D_B \quad (\text{equ. 56})$$

$$dH_1 = daD_0 + bdD_A + d(c-d)D_B \quad (\text{equ. 57})$$

$$-aG_1 = -adD_0 - caD_A - a(a-b)D_B \quad (\text{equ. 58})$$

and hence from equation 30:

$$(c+d)H_1 - (a+b)G_1 = (c^2 - d^2 + b^2 - a^2)D_B = \frac{D_B}{4} \quad (\text{equ. 59})$$

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This reveals that the start and end boundary inverse transform digital filters can reconstruct the boundary data values of the original image when low pass and high pass start and end digital filters are used in the forward  
5 transform.

#### TREE ENCODING AND DECODING

As described above, performing the forward quasi-perfect inverse transform does not reduce the number of data values carrying the image information. Accordingly,  
10 the decomposed data values are encoded such that not all of the data values need be stored or transmitted. The present invention takes advantage of characteristics of the Human Visual System to encode more visually important information with a relatively larger number of bits while  
15 encoding less visually important information with a relatively smaller number of bits.

By applying the forward quasi-perfect inverse transform to a two-dimensional array of image data values, a number of sub-band images of varying dimensions and  
20 spectral contents is obtained. If traditional sub-band coding were used, then the sub-band images would be encoded separately without reference to each other except perhaps for a weighting factor for each band. This traditional sub-band encoding method is the most readily-  
25 recognized encoding method because only the spectral response is accurately localized in each band.

In accordance with the present invention, however, a finite support wavelet is used in the analysis of an image, so that the sub-bands of the decomposition include  
30 spatially local information which indicate the spatial locations in which the frequency band occurs. Whereas most sub-band encoding methods use long filters in order to achieve superior frequency separation and maximal stop band rejection, the filter used in the present invention  
35 has compromised frequency characteristics in order to maintain good spatial locality.

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Images can be thought of as comprising three components: background intensities, edges and textures. The forward quasi-perfect inverse transform separates the background intensities (the low pass luminance and chrominance bands) from the edge and texture information contained in the high frequency bands. Ideally, enough bandwidth would be available to encode both the edges and the textures so that the image would reconstruct perfectly. The compression due to the encoding would then be entirely due to removal of redundancy within the picture. If, however, the compressed data is to be transmitted and/or stored at low data transmission rates, some visual information of complex images must be lost. Because edges are a visually important image feature, the encoding method of the present invention locates and encodes information about edges or edge-like features for transmission or storage and places less importance on encoding textural information.

There are no exact definitions of what constitutes an edge and what constitutes texture. The present invention uses a definition of an edge that includes many types of textures. An edge or an edge-like feature is defined as a spatially local phenomenon giving rise to a sharp discontinuity in intensity, the edge or edge-like feature having non-zero spectral components over a range of frequencies. Accordingly, the present invention uses a frequency decomposition which incorporates spatial locality and which is invertible. The wavelet transform realized with quasi-perfect inverse transform digital filters meets these requirements.

Because an edge has non-zero components over a range of frequencies of the decomposition in the same locality, an edge can be located by searching through the wavelet decomposition for non-zero data values that represent edges. The method begins searching for edges by examining the low frequency sub-bands of the decomposition. These bands have only a small number of data values because of

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the subsampling used in the wavelet transform and because the spatial support of each low frequency data value is large. After a quick search of the lowest frequency sub-bands, the positions of potential edges are determined.

- 5 Once the locations of the edges are determined in the lowest frequency sub-bands, these locations can be examined at a higher frequency resolutions to confirm that the edges exist and to more accurately determine their spatial locations.
- 10 Figure 23 illustrates an example of a one-dimensional binary search. There are three binary trees arranged from left to right in the decomposition of Figure 23. There are three octaves, octaves 0, 1 and 2, of decomposed data values in Figure 23. The low pass component is not
- 15 considered to be an octave of the decomposition because most of the edge information has been filtered out. Figures 24A-24D illustrate the forward transformation of a one-dimensional sequence of data values D into a sequence of transformed data values such as the tree structure of
- 20 Figure 23. The data values of the sequence of Figure 24A are filtered into low and high frequency components H and G of Figure 24B. The low frequency component of Figure 24B is then filtered into low and high frequency components HH and HG of Figure 24C. The low frequency
- 25 component HH of Figure 24C is then filtered into low and high frequency components HHH and HHG. The transformed data values of HHH block 240 of Figure 24D correspond with the low frequency component data values A, G and M of Figure 23. The transformed data values of HHG block 241
- 30 of Figure 24D correspond with the octave 2 data values B, H and N of Figure 23. The transformed data values of HG block 242 of Figure 24D correspond with the octave 1 data values of Figure 23. Similarly, the transformed data values of G block 243 correspond with the octave 0 data
- 35 values of Figure 23. Although only three trees are shown in Figure 23, the number of HHH data values in block 240 can be large and the size of the tree structure of Figure

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23 can extend in the horizontal dimension in a corresponding manner.

The encoding of a one dimensional wavelet decomposition such as the decomposition of Figure 23 is performed in similar fashion to a binary tree search. The spatial support of a given data value in a given frequency band is the same as two data values in the octave above it in frequency. Thus the wavelet decomposition is visualized as an array of binary trees such as is illustrated in Figure 23, each tree representing a spatial locality. The greater the number of transform octaves, the higher the trees extend upward and the fewer their number.

As illustrated in Figure 23, each of the data values of the decomposition represents a feature which is either "interesting" to the human visual system, or it represents a feature that is "non-interesting" to the human visual system. A data value representing an edge of an object in an image or an edge-like feature is an example of an "interesting" data value. The encoding method is a depth first search, which starts at the trunk of a tree, ascends up the branches of the tree that are interesting, and terminates at the non-interesting branches. After all the branches of a tree have been ascended until a non-interesting data value is encountered or until the top of the branch is reached, the encoding of another tree is begun. Accordingly, as the encoding method follows the interesting data values of Figure 23 from octave 2 to octave 1 to octave 0, the edge is followed from low to high frequency resolution and an increasingly better approximation to the spatial position and shape of the edge is made. Conversely, if at any stage, a non-interesting data value is found, the search is terminated for data values above that non-interesting data value. The higher frequency data values of the tree above a non-interesting data value are assumed to be non-interesting because the corresponding low frequency data



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values did not indicate the presence of an edge at this location. Any interesting data values that do exist in the higher frequency bands above a non-interesting data value in a low frequency band are rejected as noise.

5       The one-dimensional tree structure of Figure 23 is encoded as follows. The low frequency components carry visually important information and are therefore always considered to be "interesting". The method of encoding therefore starts with low frequency component A. This  
10 data value is encoded. Next, the octave 2 data value B is tested to determine if it represents an edge or an edge-like feature which is "interesting" to the human visual system. Because data value B is interesting, a token is generated representing that the bits to follow will  
15 represent an encoded data value. Interesting data value B is then encoded. Because this tree has not yet terminated, the method continues upward in frequency. Data value C of octave 1 is then tested. For purpose of this example, data value C is considered to be interesting  
20 as are data values A, B, C, D, G, H, J, L and M as illustrated in Figure 23. A token is therefore generated indicating an encoded data value will follow. After the token is sent, data value C is encoded. Because this branch has still not terminated in a non-interesting data  
25 value, the method continues upward in frequency. Data value D is tested to determine whether or not it is interesting. Because data value D is interesting, a token is generated and data value D is encoded. Because octave 0 is the highest octave in the decomposition, the encoding  
30 method tests the other branch originating from previous interesting data value C. Data value E however tests to be non-interesting. A non-interesting token is therefore generated. Data value E is not encoded and does not appear in the compressed data. With both branches  
35 originating at data value C terminated, the method proceeds down in frequency to test the remaining branches originating from the previous interesting data value B.

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Data value F is, however, determined to be non-interesting. A non-interesting token is therefore generated and data value F is not encoded and does not appear in the encoded data. Because this branch has  
5 terminated, all data values higher in frequency above data value F are considered to be non-interesting. A decoding device receiving the sequence of encoded data values and tokens can determine from the non-interesting token that all corresponding higher frequency data values were  
10 considered to be non-interesting by the encoding device. The decoding device can therefore write the appropriate data values as non-interesting and write zeroes to these locations obviating the need for the encoding device to transmit each non-interesting data value above F. With  
15 the first tree encoded, the method proceeds to the next low frequency component, data value G. This is a low frequency component and therefore is always considered to be interesting. Data value G is therefore encoded. The method then proceeds to the next tree through blocks H, I,  
20 J, K and L in that order generating interesting and non-interesting tokens and encoding interesting data values. Similarly, after the second tree is terminated, low frequency component data value M is encoded. Data value N is determined to be non-interesting so a non-interesting  
25 token is sent and the encoding of the third tree is terminated.

In accordance with another embodiment of the present invention, a two-dimensional extension of the one-dimensional case is used. Rather than using binary trees,  
30 four branch trees are used. However, to create a practical image encoding method there are also real world factors to take into account. Using a single data value to predict whether the remainder of the tree is zero, is unreliable when dealing with noisy image data. A small  
35 two-by-two block of data values is therefore used as the node element in the tree structure of the two-dimensional embodiment. A decision as to whether or not an edge is

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present is based on four data values which is more reliable than a decision based on single data value.

Figure 25 illustrates a tree structure representing a portion of the decomposition of Figure 18. The decomposition of Figure 18 may extend farther to the right and farther in a downward direction for larger two-dimensional arrays of image data values. Similarly, the tree structure of Figure 25 may extend farther to the right for larger arrays of data values. Figure 25 represents a decomposition only having octave 0 and 1 high frequency components. In the event that the decomposition had additional octaves of high frequency components, the tree structure would extend further upward. In contrast to the binary tree structure of Figure 23, the tree structure of Figure 25 is a four branch tree. The two-by-two block of four octave 1 data values HHHG is the root of a tree which extends upward in frequency to four HG two-by-two blocks. If another octave of decomposition were performed, another level of octave 2 high frequency two-by-two blocks would be inserted into the tree structure. Four HHHG octave 1 two-by-two blocks would, for example, have a single octave 2 HHHHHG block beneath them. The low frequency component would be denoted HHHHHH.

Figure 26 is a pictorial representation of the decomposition of the tree structure of Figure 25. As explained above with respect to Figure 15, the actual data values of the various denoted blocks are distributed throughout the two-dimensional array of data values. The two numbers separated by a comma in each of the boxes of Figure 25 denote the row and column of a data value of the two-dimensional array of Figure 18, respectively. Using this tree structure, it is possible to search through the transformed data values of Figure 18 encoding interesting two-by-two blocks of data values and ignoring non-interesting two-by-two blocks.

To describe how the two dimensional encoding method uses the tree structure to search through a decomposition,

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some useful definitions are introduced. First an image *decomp* is defined with dimensions *WIDTH* by *HEIGHT* decomposed to number *OCTS* of octaves. A function *Access* is defined such that given some arguments, the function  
 5 *Access* outputs the memory address of the specified data value in the wavelet decomposition *decomp*:

```
address = Access (oct, sub, x, y);
```

*oct* is the octave of the data value sought and is an integer value between 0 (the highest octave) and *OCTS-1*  
 10 (the number of octaves of transformation *OCTS* minus one). *sub* indicates which of the *HH*, *HG*, *GH* or *GG* bands of the decomposition it is that the data value sought is found. The use of *sub* = *HH* to access the low pass data values is only valid when the value of *oct* is set to that of the  
 15 lowest octave. The co-ordinates *x* and *y* indicate the spatial location from the top left hand corner of the sub-band specified by *oct* and *sub*. The range of valid values of *x* and *y* are dependent on the octave being accessed. *x* has a range of {0. . .  $WIDTH/2^{oct+1}$ }. *y* has a range of {0 .  
 20 . .  $HEIGHT/2^{oct+1}$ }.

Given the function *Access* and a wavelet decomposition, a two-by-two block of data values can be read by the function *ReadBlock*.

```
block = ReadBlock (decomp, oct, sub, x, y) {  

  25   block[0][0] = decomp[Access(oct, sub, x, y)];  

      block[0][1] = decomp[Access(oct, sub, x+1, y)];  

      block[1][0] = decomp[Access(oct, sub, x, y+1)];  

      block[1][1] = decomp[Access(oct, sub, x+1, y+1)];  

  }
```

30 The wavelet decomposition is passed to the function *ReadBlock* via the variable *decomp*. The two-by-two block of data values is returned through the variable *block*.

Once a two-by-two block of data values is read, a

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decision is made as to whether the two-by-two block is visually "interesting" and should therefore be encoded or whether it is not and hence should be discarded. The decision is made by a function called *Threshold*. The 5 arguments of the function *Threshold* are *block*, *oct* and *sub*. *Threshold* returns a boolean value *True* if the block is "interesting" and *False* if the block is "non-interesting".

If the block is determined to be interesting by the 10 function *threshold*, it is encoded using a function called *EncodeBlock*. A function *SendToken* inserts a token before the encoded block to inform a decoding device which will later decode the compressed data whether the block to follow the token has been encoded (i.e. *BlockNotEmpty*) or 15 has not been encoded (i.e. *BlockEmpty*). If a block is determined to be interesting, then a *BlockNotEmpty* token is sent, and the block is encoded; next the tree structure above the encoded block is ascended to better determine the location of the edge. The tree encoding procedure 20 *SendTree* is therefore defined recursively as follows:

```

SendTree (decomp, oct, sub, x, y, Q) {
    block = ReadBlock (decomp, oct, sub, x, y);
    If Threshold (block, oct, sub, Q) {
        SendToken (BlockNotEmpty);
25    EncodeBlock (block, oct, sub, Q);
        If (oct > 0) {
            SendTree (decomp, oct-1, sub, 2*x, 2*y, Q);
            SendTree (decomp, oct-1, sub, 2*(x+1), 2*y, Q);
            SendTree (decomp, oct-1, sub, 2*x, 2*(y+1), Q);
30    SendTree (decomp, oct-1, sub, 2*(x+1), 2*(y+1), Q);
        }
    } else SendToken (BlockEmpty);
}

```

The procedure *SendTree* is only used to encode high- 35 pass component data values. In procedure *SendTree*

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(*decomp*, *oct*, *sub*, *x*, *y*, *Q*), if the two-by-two block accessed by *ReadBlock* is determined to pass the threshold test, then *SendTree* (*decomp*, *oct*-1, *sub* 2\*X, 2\*y, *Q*) is used to test one of the next higher two-by-two blocks in 5 the decomposition tree.

The low-pass data values are not considered to form part of the tree structure. The low-pass data values are encoded using another procedure *SendLPF*. In addition, the low-pass values are encoded using a different technique 10 than that used in *EncodeBlock*, so a new procedure *EncodeBlockLPF* is required.

```

SendLPF (decomp, x, y, Q) {
    block = Readblock (decomp, OCTS-1, HH, x, y);
    EncodeBlockLPF (block, OCTS-1, Q);
15 }
```

Accordingly, to encode the entire image, *SendLPF* is applied to all the block locations within the low pass band and *SendTree* is applied to the all the block locations in the HG, GH and GG bands, within the lowest 20 octave. A procedure *SendDecomp* is therefore defined that encodes the entire image decomposition:

```

SendDecomp (decomp, Q) {
    For (y=0; y<HEIGHT/2OCTS; y=y+2)
    For (x=0; x<WIDTH/2OCTS; x=x+2) {
25     SendLPF (decomp, x, y, Q);
        SendTree (decomp, OCTS-1, HG, x, y, Q);
        SendTree (decomp, OCTS-1, GH, x, y, Q);
        SendTree (decomp, OCTS-1, GG, x, y, Q);
    }
30 }
```

Accordingly, the above functions define a method for encoding wavelet decomposed images. In terms of speed of encoding for real-world images, many of the trees are

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terminated within the initial octaves so much of the decomposition is not examined. Due to this termination of many trees in the initial octaves, many data values need not be encoded which results in reducing the memory bandwidth and block processing required to implement the compression/decompression method. Provided the functions *Threshold*, *EncodeBlockLPF* and *Access* require only simple calculations, the decomposed data values are rapidly encoded.

10 To implement the function *Access*, a table containing all the addresses of the data values of the two-dimensional tree decomposition may be accessed using the variables *x*, *y*, *sub* and *oct*. For a small image having a small number of data values, this table lookup approach is  
 15 reasonable. For images having, for example, approximately 80 different values of *x*, 60 different values of *y*, four different values of *sub*, and 3 or 4 values for *oct*, this table would contain approximately 150,000 10-bit locations. A less memory intensive way of determining the  
 20 same *X* and *Y* addresses from the same variables is desirable.

In accordance with one embodiment of the present invention, a function is used to determine the *X* and *Y* addresses from the variables *x*, *y*, *sub* and *oct*. Address  
 25 *X*, for example, may be determined as follows:

$$X = ((x \ll 1) + (sub \gg 1)) \ll oct$$

where  $\ll$  denotes one shift to the right of value *x* and  
 where  $\gg$  denotes one shift to the left.

Address *Y*, for example, may be determined as follows:

30 
$$Y = ((y \ll 1) + (1 \& sub)) \ll oct$$

where  $\&$  denotes a bit-wise AND function.

In a high performance system, the function *Access* may be implemented according to the following method. The

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recursive function call and the table lookup methods described above are often too slow to implement in real time software or in hardware. Figures 27 and 28 illustrate how the tree decomposition of Figure 25 is traversed in order to generate tokens and encode two-by-two blocks of data values. The X and the Y in Figures 27 and 28 denote coordinate addresses in the two-dimensional matrix of Figure 18. In order to traverse the tree of the decomposition of Figure 25, it is necessary to be able to determine the X and Y addresses of the data values represented in Figure 25. Figure 27 illustrates how the X and Y address of a two-by-two block of data values are determined for those two-by-two blocks of data values located in octave 0 of the decomposition of Figure 25. Similarly, Figure 28 illustrates how the X and Y addresses of the three two-by-two blocks of data values in octave 1 of the decomposition as well as the one two-by-two block of data values of the low pass component of the decomposition of Figure 25 are determined. X as well as Y are each functions of oct, TreeRoot, and sub. The values of sub<sub>x</sub> and sub<sub>y</sub> are determined by the sub-band of the two-by-two block of data values sought.

Figure 29 is a chart illustrating the values of sub<sub>x</sub> and sub<sub>y</sub> for each sub-band of the decomposition. If, for example, a two-by-two block of data values is sought in the HH band, then the values of sub<sub>x</sub> and sub<sub>y</sub> are 0 and 0, respectively. The values TreeRoot<sub>x</sub> and TreeRoot<sub>y</sub> together denote the particular tree of a decomposition containing the particular two-by-two block of the data values sought.

In Figures 27 and 28, the rectangles represent digital counters. The arrows interconnecting the rectangles indicate a sequence of incrementing the counters. For example, the right most rectangle in Figure 27, which is called counter C1, has a least significant bit represented in Figure 27 as bit C1<sub>0</sub>, and a most significant bit represented as bit C1<sub>3</sub>. Similarly, the next rectangle to the left in Figure 27 represents a



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digital counter C2 having two bits, a least significant bit C2, and a most significant bit C2,. The structure of the X, Y address depends on the octave in which the two-by-two block of data values being sought resides. To  
5 generate the X, Y address in octave oct = 1, the counter C1 is not included, the sub<sub>1</sub> and sub<sub>2</sub> bits indicating the sub-band bits are shifted one place to the left, and the least significant bits are filled with zeros. The incrementing of the counters in Figure 28 proceeds as  
10 illustrated by the arrows.

To determine the X and Y addresses of the four data values of the low pass component HHHH of Figure 25, Figure 28 is used. Because the two-by-two block of data values being sought is a two-by-two block of the low pass  
15 component, the values of sub<sub>1</sub> and sub<sub>2</sub> are 0, 0 as required by the table of Figure 29. The C2 counter of Figure 28 increments through the four possible values of C2, and C2, to generate the four addresses in the two-by-two block of data values of the HHHH in the low pass component of  
20 Figure 25. The value of TreeRoot<sub>1</sub> and TreeRoot<sub>2</sub> are zeroes because this is the first tree of the decomposition. For subsequent trees of the decomposition, TreeRoot<sub>1</sub> and TreeRoot<sub>2</sub> are incremented as illustrated by the arrows in Figure 28 so that the X and Y addresses of the other two-  
25 by-two blocks of data values in the low pass component of the tree decomposition can be determined. After this HHHH two-by-two block of data values is located, the four data values are encoded and the search through the tree structure proceeds to the two-by-two block of data values  
30 in octave 1 denoted HHHG in Figure 25. To determine the X and Y addresses of the four data values of this two-by-two block, the value of bits sub<sub>1</sub> and sub<sub>2</sub> are changed in accordance with Figure 29. Because this two-by-two block is in the HG sub-band, the values of sub<sub>1</sub> and sub<sub>2</sub> are 0  
35 and 1, respectively. The C2 counter is then incremented through its four values to generate the four addresses of the four data values in that block. Supposing, that this

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two-by-two block is determined to be "interesting" then an interesting token is sent, each of the four data values of the block are encoded, and the tree is then ascended to the two-by-two block of data values in octave 0 denoted HG#1. These four addresses are determined in accordance with Figure 27. Because the sub-band is sub-band HG, the values of the bits  $sub_x$  and  $sub_y$  are 0 and 1, respectively. Counter C1 is then incremented so that the four addresses illustrated in the two-by-two block octave 0 HG#1 of Figure 25 are generated. If the two-by-two block is interesting, then the interesting token is sent and the four data values are encoded. If the two-by-two block is determined not to be interesting, then a non-interesting token is sent and the four data values are not encoded.

The search through the tree structure of the decomposition then proceeds to octave 0 block HG#2. After the four addresses of the octave 0 block HG#1 are generated, the C2, bit of the C2 counter is incremented in accordance with the arrows shown in Figure 27. Accordingly, the octave 0 block HG#2 is addressed when once again the C1 counter increments through its four states. If the data values of this two-by-two block are determined to be "interesting", an interesting token is sent followed by the encoded data values. If the data values of the two-by-two block are determined to be non-interesting, then a non-interesting token is sent. After all the search of the four two-by-two blocks of the octave 0 HG sub-band are searched, then that HG tree is terminated and the search proceeds to determine the four addresses of the four data values of the octave 1 HHGH two-by-two block. In accordance with this technique, it is possible to traverse the structure of the decomposition and determine the addresses of any two-by-two block in any octave or any sub-band with minimum overhead. Moving between consecutive addresses or descending trees is a simple operation when compared to the snaking address path used by other compression methods such as JPEG.

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When implemented in software, this technique enables real time compression and decompression whereas other techniques may be too slow. If implemented in hardware, this technique provides for a reduced gate count and an efficient implementation. Although this example shows one way of traversing the tree structure of wavelet transform decomposition, it is possible to traverse the tree structure in other ways simply by changing the control structure represented in Figures 27 and 28 to allow for a different traversal of the tree structure. For example, all of the low pass HHHH blocks can be located and encoded first followed by all of the HHHG tree of the decomposition, and then all of the HHGH trees, and then all of the HHGG trees.

15

## QUANTIZATION

Each data value of each two-by-two block of the tree decomposition which is determined to be "interesting" is quantized and then Huffman encoded. A linear mid-step quantizer with double-width-0 step is used to quantize each of the data values. Figure 30 is an illustration of the quantization of a 10-bit twos complement data value. The range of the 10-bit data value to be quantized ranges from -512 to 511 as illustrated by the numbers above the horizontal line in Figure 30. This range is broken up into a plurality of steps. Figure 31 represents one such step of data values which extends from 128 to 256 in Figure 30. All incoming data values having values between 128 and 255 inclusive are quantized by dividing the data value by the value *qstep*. Accordingly, the data value A having a value of 150 as illustrated in Figure 31 is divided by the *qstep* value 128 and results in a *qindex* number of 1. Integer division is used to generate *qindex* and the fractional part of the remainder is discarded. Once the *qindex* number is determined, the *qindex* number is Huffman encoded. An overall Q value is sent once per frame of compressed data values. The value *qstep* is

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determined from the overall  $Q$  value as described below.

To inverse quantize the  $qindex$  number and the  $qstep$  value to determine the value of the transformed data values before inverse transformation, the device decoding the incoming quantized values calculates the value of  $qstep$  using the value of  $Q$  according to a method described below. Once the value of  $qstep$  is determined,  $qindex$  for a given data value is multiplied by  $qstep$ .

In the example of Figure 31,  $qindex$  value 1 times  $qstep$  128 results in an inverse quantized value of 128. If this inverse quantized value of 128 were used, however, all the data values in the step 128 through 255 would be inverse quantized to the value of 128 at the left end of the step. This would result in unacceptably large errors. On the other hand, if all the data values in the range of Figure 31 were inverse quantized to the mid-step value 191, then less error would result. Accordingly, an inverse quantized value  $qvalue$  can be calculated from  $qindex$  and  $qstep$  as follows:

$$qvalue(qindex, qstep) = \begin{cases} qindex \cdot qstep - \left( \frac{qstep}{2} - 1 \right) & \text{if } qindex < 0 \\ 0 & \text{if } qindex = 0 \\ qindex \cdot qstep + \left( \frac{qstep}{2} - 1 \right) & \text{if } qindex > 0 \end{cases}$$

The human visual system, however, has different sensitivities to quantization errors depending upon the particular sub-band containing the quantized data values. The human visual system performs complex non-linear processing. Although the way the human visual system relates image intensities to recognizable structures is not well understood, it is nevertheless important to take advantage of as much information about the human visual system as possible in order to maximize compression ratio versus picture quality. The wavelet transform approximates the initial image processing performed by the human brain. Factors such as spatial frequency response and Weber's Law can therefore be applied directly to the

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wavelet transformed data values because the transformed data values are in a convenient representation.

Figure 32 shows the sensitivity of the human eye to spatial frequency. Spatial frequency is measured in 5 cycles  $c$  per visual angle  $\theta$ . A screen is positioned at a distance  $d$  from an observer as illustrated in Figure 33. A light of sinusoidally varying luminance is projected onto the screen. The spatial frequency is the number of luminance cycles  $c$  per visual degree  $\theta$  at distance  $d$ .

10 Note from Figure 32 that the sensitivity of the human eye varies with spatial frequency. Accordingly, the value of  $gstep$  is varied depending on the octave and sub-band of the data valve being quantized. The  $gstep$  at which a data valve is quantized is determined from the variables

15  $oct$ ,  $sub$  and  $Q$  for that data valve as follows:

$$gstep(oct, sub, Q) = Q * hvs\_factor(oct, sub)$$

$$hvs\_factor(oct, sub) = \begin{cases} \sqrt{2} & \text{if } sub=GG \\ 1 & \text{otherwise} \end{cases} * \begin{cases} 1.00 & \text{if } oct=0 \\ 0.32 & \text{if } oct=1 \\ 0.16 & \text{if } oct=2 \\ 0.10 & \text{if } oct=3 \end{cases}$$

The scaling factors 1.00, 0.32, 0.16 and 0.10 relate to the spatial frequency scale of Figure 32 to take into

20 account the frequency dependent sensitivity of the human eye.

It is to be understood that scaling factors other than 1.00, 0.32, 0.16 and 0.10 could be used. For example, other scaling factors can be used where the

25 quantizer is used to compress audio data which is received by the human ear rather than by the human eye. Moreover, note that the sub-band GG is quantized more heavily than the other sub-bands because the sub-band GG contains diagonal information which is less important to the human

30 eye than horizontal and vertical information. This method can also be extended down to the level of two-by-two blocks of data values to further tailor the degree of quantization to the human visual system. The function

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*hvs\_factor* which has only two parameters in the presently described embodiment is only one embodiment of the present invention. The function *hvs\_factor*, for example, can take into account other characteristics of the human visual system other than oct and sub, such as the luminance of the background and texture masking.

#### THRESHOLDING

For each new two-by-two block of data values in the tree decomposition, a decision must be made as to whether the block is "interesting" or "non-interesting". This can be done by the function *threshold*:

$$\text{threshold}(\text{block}, \text{limit}) = \text{limit} > \sum_{y=0}^1 \sum_{x=0}^1 |\text{block}[y][x]| \quad (\text{equ. 60})$$

The sum of the absolute values of the data values of the block *block* is determined as is represented by the double summation to the right of the less than sign and this value is compared to a threshold value *limit*.

"Interesting" blocks are those blocks, for which the sum of the absolute values of the four data values exceeds the value *limit*, whereas "non-interesting" blocks are those blocks for which the sum is less than or equal to the value *limit*.

The value *limit* takes into account the variable quantizer step size *qstep* which varies with octave. For example, a two-by-two block of data values could be determined to pass the test *threshold*, but after quantizing by *qstep* could result in four zero quantized values. For example, all data values between -128 and 127 are quantized to have a quantized *qindex* of zero as is shown in Figure 30 even if some of those data values are determined to correspond with an "interesting" two-by-two block. For this reason, the value *limit* is calculated according to the equation:

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$$\text{limit} = 4 * B_{\text{threshold}} * q_{\text{step}} \quad (\text{equ. 61})$$

In this equation " $B_{\text{threshold}}$ " is base threshold image factor. In the presently described example, this base threshold is equal to 1.0. The value of 1.0 for the base threshold  $B_{\text{threshold}}$  was determined through extensive experimentation on test images. The factor 4 in equation 61 is included to account for the fact that there are four data values in the block under consideration. In this way blocks are not determined to be interesting, the data values for which the quantizer will later reduce to zeros. This weighted threshold factor  $\text{limit}$  also reduces the number of operations performed in the quantizer because a fewer number of data values are quantized.

#### HUFFMAN CODING

The wavelet transform produces transformed data values whose statistics are vastly different from the data values of the original image. The transformed data values of the high-pass sub-bands have a probability distribution that is similar to an exponential or Laplacian characteristic with mean zero.

Figure 34 shows the distribution of high pass data values in a four octave wavelet decomposition of the test image Lenna. Figure 35 shows the distribution of the data values of the test image Lenna before wavelet transformation. The low-pass component data values have a flat distribution that approximates the distribution of luminance and chrominance values in the original image. The high and low pass data values are encoded differently for this reason.

The low pass component data values are encoded by the function *EncodeBlockLPF* as follows:

```

EncodeBlockLPF ( block, OCT-1, Q) {
    Output ( block[0][0]/qstep( OCT-1, HH, Q));
    Output ( block[0][1]/qstep( OCT-1, HH, Q));
    Output ( block[1][0]/qstep( OCT-1, HH, Q));

```

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```
Output ( block[1][1]/qstep( OCT-1, HH, Q));}
```

After encoding, the low-pass data values are quantized and output into the compressed data stream. The low pass data values are not Huffman encoded.

5       The high frequency component data values which pass the threshold test are quantized and Huffman encoded to take advantage of their Laplacian distribution. Function *EncodeBlock* performs the quantization and the Huffman encoding for each of the four data values of an

10 interesting high frequency component block block. In the function *EncodeBlock*, the variable *sub* is provided so that when function *qstep* is called, different quantization *qstep* values can be used for different high frequency component sub-bands. The function *huffman* performs a

15 table lookup to a fixed Huffman code table such as the table of Table 3. The function *EncodeBlock* is defined as follows:

```
EncodeBlock (block, oct, sub, Q) {
    Output(huffman(block[0][0]/qstep(oct, sub, Q)));
20   Output(huffman(block[0][1]/qstep(oct, sub, Q)));
    Output(huffman(block[1][0]/qstep(oct, sub, Q)));
    Output(huffman(block[1][1]/qstep(oct, sub, Q)));
}
```



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<i>qindex</i>	Huffman code
-38 . . . -512	1 1 0 0 0 0 0 0 1 1 1 1 1 1 1
-22 . . -37	1 1 0 0 0 0 0 0 1 1 1 1 ( <i> qindex </i> -22)
-7 . . -21	1 1 0 0 0 0 0 0 ( <i> qindex </i> -7)
5     -6	1 1 0 0 0 0 0 1
.	.
.	.
.	.
-2	1 1 0 1
10     -1	1 1 1
0	0
1	1 0 1
2	1 0 0 1
.	.
.	.
15     .	.
6	1 0 0 0 0 0 0 1
7 . . 21	1 0 0 0 0 0 0 0 ( <i> qindex </i> -7)
22 . . 37	1 0 0 0 0 0 0 0 1 1 1 1 ( <i> qindex </i> -22)
20     38 . . 511	1 0 0 0 0 0 0 0 1 1 1 1 1 1 1

Table 3

The second bit from the left in the Huffman code of Table 3 is a sign bit. The value  $|qindex|-7$  is represented with 4 bits in the case  $7 \leq |qindex| \leq 21$ . The value  $|qindex|-22$  is represented with 4 bits in the case  $22 \leq |qindex| \leq 37$ .

## ENCODING OF TOKENS

At high compression ratios the number of bits in the compressed data stream used by tokens may be reduced by amalgamating groups of "non-interesting" tokens. This can be achieved by introducing new tokens. In accordance with one embodiment of the present invention, two new tokens, *OctEmpty* and *OctNotEmpty* are used. For a high pass component block in a tree above octave zero, there are four branches. The additional pair of tokens indicate

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whether all four are non-interesting. If all four are non-interesting, only a single OctEmpty token need be sent. Otherwise, an OctNotEmpty token is generated before the four branches are encoded. The particular token  
5 scheme described above was selected more to simplify the hardware and software implementations than it was to achieve in the best compression ratio possible. Other methods of representing relatively long sequences of token  
10 bits in the compressed data stream using other tokens having a relatively fewer number of bits may be used in place of the tokens OctEmpty and OctNotEmpty to achieve higher compression ratios.

#### VIDEO ENCODING AND DECODING

In comparison with the coding of a still image, the  
15 successive images of a video sequence typically contain much redundant information. The redundancy of this information is used to reduce the bit rate. If a location in a new frame of the video contains the same or substantially the same information as a corresponding  
20 location in the previous old frame of video, that portion of the new frame need not be encoded and introduced into the compressed data. This results in a reduction in the total number of bits in the encoded bit stream.

Figure 36 illustrates a video encoder 31 and a video  
25 decoder 32. A video input signal is transformed by a forward wavelet transform block 33, the output of which is written to a new frame store 34. The first frame of video information in the new frame store 34 is referred to as the new frame because no previous frame exists in the old  
30 frame store 35 for containing an old frame. A comparison tree encoder 36 therefore generates tokens and transformed data values as described above from the data values output from new frame store 34. The transformed data values are quantized by quantizer 37 into gindex levels. These  
35 gindex levels are then Huffman coded by the Huffman encoder 38. The resulting encoded data values are then

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combined with the tokens in buffer 38A to form a decompressed data bit stream 39.

An essential part of this method is that the old frame present in the video encoder 31 is exactly the same 5 as the old frame 40 present in the video decoder 32. This allows the decoder 32 to be able to correctly decode the encoded bit stream 39 due to the fact that the encoded bit stream contains differences between new and old images and due to the fact that parts of the new frame are not sent 10 due to compression. An inverse quantizer 41 is therefore provided in the video encoder 31 to inverse quantize the *qindex* levels and to store the old frame as sent into old frame store 35 for future comparison with the next frame of the video input signal.

15 In the video decoder 32, the compressed data stream 39 is received by a buffer 42. The tokens are separated from the Huffman encoded *qindex* levels. The Huffman encoded *qindex* levels are supplied to a Huffman decoder 43, the output of which is supplied to an inverse 20 quantizer 44. The output of the inverse quantizer 44 is written into old frame store 40 under the control of the comparison tree decoder 45. Comparison tree decoder 45 determines what is written into the old frame store 40, depending in part on the tokens received from buffer 42. 25 Once a new frame of transformed data values is present in old frame store 40, an inverse wavelet transform 46 inverse transforms that frame of transformed data values into a corresponding video output signal. To prevent the inverse wavelet transform 46 from overwriting and 30 therefore corrupting the contents of old frame store 40 when it reconstructs data values corresponding to the original new frame data values, an intermediate frame store 47 is maintained.

The octave one HHNG, HHGH, HHGG, and HHHH from Figure 35 25 are read from the old frame store 40 by the inverse wavelet transform 46 to perform the octave 1 inverse transform as described above. However, the resulting

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octave 0 HH sub-band, output from the inverse wavelet transform 46 is now written to the intermediate frame store 47, so as not to corrupt the old frame store 40. For the octave 0 inverse wavelet transform, the HG, GH, and GG 5 sub-bands are read from the old frame store 40, and the HH sub-band is read from the intermediate frame store 47, to complete the inverse wavelet transform.

When the second frame of compressed video data 39 is received by the video decoder 32, the tokens received by 10 the comparison tree decoder 45 are related to the contents of the previous frame of video information contained in old frame store 40. Accordingly, the video decoder 32 can reconstruct the latest frame of video data using the contents of the frame store 40 and the data values encoded 15 in the compressed data stream 39. This is possible because the compressed data stream contains all the information necessary for the video decoder 32 to follow the same traversal of the tree of the decomposition that the encoder used to traverse the tree in the generation of 20 the compressed data stream. The video decoder 32 therefore works in lock step with the video encoder 31. Both the encoder 31 and the decoder 32 maintain the same mode at a corresponding location in the tree. When the encoder 31 determines a new mode, it incorporates into the 25 compressed data stream 39 a corresponding token, which the video decoder 32 uses to assume that new mode.

Figure 37 illustrates the modes of operation of one possible embodiment of the present invention. To explain the operation of the video encoder 31 and the video 30 decoder 32, an example is provided. The initial frame of the video sequence is processed by the video encoder 31 in still mode. Still mode has three sub-modes: STILL, VOID\_STILL, and LPF\_STILL. The low pass two-by-two blocks of data values of the decomposition cause the comparison 35 tree encoder 36 of video encoder 31 to enter the LPF\_STILL sub-mode. In this sub-mode, the four data values of the two-by-two block are quantized but are not Huffman

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encoded. Similarly, no token is generated. The successive low pass component two-by-two blocks of data values are successively quantized and output into the compressed data stream 39.

5       Next, the lowest frequency octave of one of the sub-bands is processed by the comparison tree encoder 36. This two-by-two block of data values corresponds with block HHHG illustrated in Figure 25. The four data values of this two-by-two block are tested against the threshold  
10 limit to determine if it is "interesting". If the two-by-two block HHHG is interesting, then a single bit token 1 is generated, as illustrated in Figure 37, the mode of the comparison tree encoder remains in STILL mode, and the four data values of the two-by-two block HHHG are  
15 successively quantized and encoded and output into the compressed data stream 39.

For the purposes of this example, block HHHG is assumed to be interesting. The tree structure of Figure 25 is therefore ascended to octave 0 two-by-two block  
20 HG#1. Because the comparison tree encoder 31 remains in the STILL mode, this block is encoded in the STILL mode. The four data values of block HG#1 are tested to determine whether or not they are interesting. This sequence of testing the successive blocks of the tree structure is  
25 repeated as described above.

After the traversal of the four octave 0 sub-blocks HG#1, HG#2, HG#3 and HG#4, the comparison tree encoder 36 proceeds in the tree structure to the two-by-two block of data values in octave 1, block HHGH. For purposes of this  
30 example, this two-by-two is non-interesting. After the comparison tree encoder 36 reads the four data values, the result of the threshold test indicates a non-interesting two-by-two block. As illustrated in Figure 37, the encoder 31 which is in the still mode now generates a  
35 single bit token 0 and the comparison tree encoder 36 enters the VOID\_STILL sub-mode. Although no additional information is output into the compressed data stream 39,

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the comparison tree encoder 36 proceeds to write 0's into the four locations of the two-by-two block HHGH, as well as all the locations of the two-by-two blocks in the tree above the non-interesting two-by-two block HHGH. In the 5 example of Figure 25, the comparison tree encoder 36 writes 0's into all the addresses of blocks HHGH, GH#1, GH#2, GH#3 and GH#4. This zeroing is performed because the video decoder 32 will not be receiving the data values corresponding to that tree. Rather, the video decoder 32 10 will be receiving only a non-interesting token, a single bit 0. The video decoder 32 will therefore write zeros into frame store 40 in the remainder of the corresponding tree. In order to make sure that both the video encoder 31 and the video decoder 32 have exactly the same old 15 frame 35 and 40, the video encoder too must zero out those non-interesting blocks.

After the first frame of video data has been encoded and sent in STILL mode, the next frame of video data is processed by the video encoder 31. By default, the 20 encoder now enters SEND mode. For lowpass frequency component two-by-two blocks, the video encoder 31 enters the LPF\_SEND mode as illustrated in Figure 37. The encoding of such a lowpass component two-by-two block corresponds with the encoding of two-by-two block HHHH in 25 Figure 25. However, now the comparison tree encoder 36 has both a new frame in frame store 34 as well as an old frame in frame store 35. Accordingly, the comparison tree encoder 36 determines the arithmetic difference of the respective four data values in the new frame from the four 30 data values in the old frame at the corresponding position and compares the sum of those differences with a compare threshold. The compare threshold, compare, is calculated from a base compare threshold "Bcompare" as in the case of the previous threshold which determines which blocks are 35 interesting, similar to equations 60 and 61. If the sum of the differences is less than the compare threshold, then the video encoder 31 sends a single bit token 0 and

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remains in the LPF\_SEND mode, as illustrated in Figure 37. The video encoder 31 does not transmit any data values corresponding to the lowpass frequency component two-by-two block.

5 If, on the other hand, the sum of the arithmetic differences exceeds the compare threshold, then a single bit token 1 is generated, as illustrated in Figure 37. In this case, the video encoder 31 sends the arithmetic differences of each of the successive four data values of  
10 the new frame versus the old frame to the quantizer 37 and then to the Huffman encoder 38. The arithmetic differences are encoded and sent rather than sending the actual data values because this results in fewer bits due to the fact that the two blocks in the new and old frames  
15 are quite similar under normal circumstances.

When the video encoder 31 proceeds to encode the octave 1 sub-band HHHG, as illustrated in Figure 25, the video encoder 31 enters the SEND mode, as illustrated in Figure 37. In this mode, the comparison tree encoder 36  
20 compares the data values of the new two-by-two block with the data values of the old two-by-two block and performs a series of arithmetic operations to generate a series of flags, as illustrated in Figure 38. Based on these flags, the video encoder 31 generates a 2-bit token and enters  
25 one of four new modes for that two-by-two block. If, for example, the two-by-two block HHHG in Figure 25 is received by the video encoder 31, then flags *ozflag*, *nzflag*, *new\_z*, *noflag*, *motion*, *origin*, and *no\_z* are determined. The values of these flags are determined as:

$$30 \quad nz = \sum_{x=0}^1 \sum_{y=0}^1 |new[x][y]| \quad (\text{equ. 62})$$

$$no = \sum_{x=0}^1 \sum_{y=0}^1 |new[x][y] - old[x][y]| \quad (\text{equ. 63})$$

$$oz = \sum_{x=0}^1 \sum_{y=0}^1 |old[x][y]| \quad (\text{equ. 64})$$

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$nzflag = nz < limit$  (equ. 65)  
 $noflag = no < compare$  (equ. 66)  
 $origin = nz \leq no$  (equ. 67)  
 $motion = ((nz + oz) \ll oct) \leq no$  (equ. 68)  
5  $new\_z = |new[x][y]| < qstep, 0 \leq x, y, \leq 1$  (equ. 69)  
 $no\_z = |new[x][y] - old[x][y]| < qstep, 0 \leq x, y \leq 1$  (equ. 70)  
 $ozflag = \{old[x][y] = 0; \text{ for all } 0 \leq x, y \leq 1\}$  (equ. 71)

Based on the values of these flags, the new mode for  
10 the two-by-two block HHG is determined, from Figure 38.

If the new mode is determined to be the SEND mode,  
the 2-bit token 11 is sent as indicated in Figure 37. The  
arithmetic differences of the corresponding four data  
values are determined, quantized, Huffman encoded, and  
15 sent into the compressed data stream 39.

In the case that the flags indicate the new mode is  
STILL\_SEND, then the 2-bit token 01 is sent and the new  
four data values of the two-by-two block are quantized,  
Huffman encoded, and sent. Once having entered the  
20 STILL\_SEND mode, the video encoder 31 remains in the  
STILL\_SEND mode until the end of the tree has been  
reached. In this STILL\_SEND mode, a single bit token of  
either 1 or 0 precedes the encoding of each block of data  
values. When the VOID mode is entered from STILL\_SEND  
25 mode, the video encoder 31 generates a single bit 0 token,  
then places zeros in the corresponding addresses for that  
two-by-two block, and then proceeds to place zeros in the  
addresses of data values of the two-by-two blocks in the  
tree above.

30 In the event that the flags indicate that the video  
encoder 31 enters the VOID mode from SEND mode, a 2-bit  
token 10 is generated and the four data values of that  
two-by-two block are replaced with zeros. The VOID mode  
also results in the video encoder 31 placing zeros in all  
35 addresses of all data values of two-by-two blocks in the  
tree above.

In the case that the flags indicate that there is no



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additional information in the tree being presently encoded, namely, the new and the old trees are substantially the same, then a 2-bit token of 00 is generated and the video encoder 31 proceeds to the next 5 tree in the decomposition.

In general, when the video encoder 31 enters VOID mode, the video encoder will remain in VOID mode until it determines that the old block already contains four zero data values. In this case, there is no reason to continue 10 in VOID mode writing zeros into that two-by-two block or the remainder of the blocks in the tree above because it is guaranteed that the old tree already contains zeros in these blocks. This is true because the old tree in frame store 35 has previously been encoded through the inverse 15 quantizer 41.

Because the video decoder 32 is aware of the tree structure of the decomposition, and because the video encoder 31 communicates with the video decoder 32 using tokens, the video decoder 32 is directed through the tree 20 structure in the same manner that the video encoder 31 traverses the tree structure in generating the compressed data stream 39. In this way the video decoder 32 writes the appropriate data values from the decompressed data stream 39 into the corresponding positions of the old data 25 frame 40. The only flag needed by the video decoder 32 is the ozflag, which the video decoder obtains by reading the contents of old frame store 40.

#### RATE CONTROL

All transmission media and storage media have a 30 maximum bandwidth at which they can accept data. This bandwidth can be denoted in terms of bits per second. A standard rate ISDN channel digital telephone line has, for example, a bandwidth of 64 kbits/sec. When compressing a sequence of images in a video sequence, depending upon the 35 amount of compression used to compress the images, there may be a relatively high number of bits per second

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generated. This number of bits per second may in some instances exceed the maximum bandwidth of the transmission media or storage device. It is therefore necessary to reduce the bits per second generated to insure that the maximum bandwidth of the transmission media or storage device is not exceeded.

One way of regulating the number of bits per second introduced into the transmission media or storage device involves the use of a buffer. Frames having a high number of bits are stored in the frame buffer, along with frames having a low number of bits, whereas the number of bits per second passing out of the buffer and into the transmission media or storage device is maintained at a relatively constant number. If the buffer is sufficiently large, then it is possible to always achieve the desired bit rate as long as the overall average of bits per second being input into the buffer over time is the same or less than the maximum bit rate being output from the buffer to the transmission media or storage device.

There is, however, a problem associated with large buffers in video telephony. For a large buffer, there is a significant time delay between the time a frame of video data is input into the buffer and time when this frame is output from the video buffer and into the transmission media or storage device. In the case of video telephony, large buffers may result in large time delays between the time when one user begins to speak and the time when another user begins to hear that speech. This time delay, called latency, is undesirable. For this reason, buffer size is specified in the standard H.261 for video telephony.

In accordance with one embodiment of the present invention, a rate control mechanism is provided which varies the number of bits generated per frame, on a frame by frame basis. Due to the tree encoding structure described above, the number of bits output for a given frame is dependent upon the number of trees ascended in

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the tree encoding process. The decisions of whether or not to ascend a tree are made in the lowest high frequency octaves of the tree structure. As can be seen from Figure 25, there are relatively few number of blocks in the 5 lowest frequency of the sub-bands, as compared to the number of blocks higher up in the sub-band trees. Given a particular two-by-two block in the tree structure, it is possible to decrease the value of  $Q$  in the equation for the threshold limit until that particular block is 10 determined to be "interesting". Accordingly, a particular  $Q$  is determined at which that particular block becomes interesting. This process can be done for each block in the lowest frequency HG, GH and GG sub-bands. In this way, a histogram is generated indicating a number of 15 two-by-two blocks in the lowest frequency of the three sub-bands which become interesting at each particular value of  $Q$ .

From this histogram, a relationship is developed of the total number of two-by-two blocks in the lowest 20 frequency of the three sub-bands which are interesting for a given value of  $Q$ . Assuming that the number of blocks in the lowest frequency octave of the three sub-bands which are interesting for a given value of  $Q$  is representative of the number of bits which will be generated when the 25 tree is ascended using that given value of  $Q$ , it is possible to determine the value of  $Q$  at which a desired number of bits will be generated when that frame is coded with that value of  $Q$ . Furthermore, the greater the threshold is exceeded, the more bits may be needed to 30 encode that tree. It is therefore possible to weight by  $Q$  the number of blocks which are interesting for a given value of  $Q$ . Finally, the  $Q$  values so derived should be averaged between frames to smooth out fluctuations.

The encoder model RM8 of the CCITT Recommendation 35 H.261 is based on the DCT and has the following disadvantages. The rate control method used by RM8 is a linear feedback technique. Buffer fullness is

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proportional to  $Q$ . The value of  $Q$  must be adjusted after every group of blocks (GOB) to avoid overflow or underflow effects. This means that parts of the image are transmitted at a different level quality from other parts.

5 During parts of the image where little change occurs,  $Q$  drops which can result in uninteresting areas being coded very accurately. The objects of interest are, however, usually the moving ones. Conversely, during the coding of areas of high activity,  $Q$  rises creating large errors in

10 moving areas. When this is combined with a block based transform, the errors can become visually annoying.

The method of rate control described in connection with one embodiment of the present invention uses one value of  $Q$  for the whole frame. The value of  $Q$  is only

15 adjusted between frames. All parts of an image are therefore encoded with the same value of  $Q$ . Moreover, because the tree structure allows a relatively few number of blocks to be tested to determine an estimate of the number of bits generated for a given frame, more

20 intelligent methods of varying  $Q$  to achieve an overall desired bit rate are possible than are possible with conventional compression/decompression techniques.

#### TREE BASED MOTION ESTIMATION

Figure 39 represents a black box 1 on a white

25 background 2. Figure 40 represents the same black box 1 on the same white background 2 moved to the right so that it occupies a different location. If these two frames of Figures 39 and 40 are encoded according to the above described method, there will be a tree in the wavelet

30 decomposition which corresponds with the white-to-black edge denoted 3 in Figure 39. Similarly, there will be another tree in the wavelet decomposition of the image of Figure 40 which represents the white-to-black edge 3' the wavelet decomposition of the image of Figure 40. All of

35 the data values corresponding to these two trees will be determined to be "interesting" because edges result in

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interesting data values in all octaves of the decomposition. Moreover, due to the movement of the corresponding edge of black box 1, all the data values of the edges of both of these two trees will be encoded as 5 interesting data values in the resulting compressed data stream. The method described above therefore does not take into account that it is the same data values representing the same white-to-black edge which is present in both images but which is just located at a different 10 location.

Figure 41 is a one dimensional representation of an edge. The corresponding low path component data values are not illustrated in Figure 41. Data values 4, 5, 6, 7, 8, and 9 represent the "interesting" data values of Figure 15 41 whereas the other data values have low data values which makes those blocks "non-interesting". In the representation of Figure 41, data values 4 and 5 are considered a single two data value block. Similarly, blocks 6 and 7 are considered a single block and blocks 8 20 and 9 are considered a single block. Figure 41, although it is a one dimensional representation for ease of illustration, represents the edge 3 of the frame of Figure 39.

Figure 42 represents the edge 3' shown in Figure 40. 25 Figure 42 indicates that the edge of black box 1 has moved in location due to the fact that the values 19 and 21 which in Figure 41 were in the two data value block 8 and 9 are located in Figure 42 in the two data value block 10 and 11. In the encoding of Figure 42, rather than 30 encoding and sending into the compressed data stream the values 19 and 21, a control code is generated which indicates the new locations of the two values. Although numerous control codes are possible, only one embodiment is described here.

35 When the two data value block 10 and 11 is tested to determine whether it is interesting or not, the block tests to be interesting. The neighboring blocks in the

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old frame are, however, also tested to determine whether the same values are present. In this case, the values 19 and 21 are determined to have moved one two data value block to the right. An "interesting with motion" token is therefore generated rather than a simple "interesting" token. A single bit 1 is then sent indicating that the edge represented by values 19 and 21 has moved to the right. Had the edge moved to the left, a control code of 0 would have been sent indicating that the edge represented by values 19 and 21 moved one location to the left. Accordingly, in the encoding of Figure 42, an "interesting with motion" token is generated followed by a single control code 1. The interesting values 19 and 21 therefore need not be included in the compressed data stream. The video decoder receiving this "interesting with motion" token and this control code 1 can simply copy the interesting values 19 and 21 from the old frame into the indicated new location for these values in the new frame obviating the need for the video encoder to encode and transmit the actual interesting data values themselves. The same token and control codes can be sent for the two data values corresponding to a block in any one of the octaves 0, 1 or 2.

Figure 43 represents the motion of the edge 3 of Figure 39 to a new location which is farther removed than is the new location of black box 1 shown in Figure 40. Accordingly, it is seen that the values 20 and 21 are located to the right at the two data value block 12 and 13. In the encoding of this two data value block 12 and 13 a token indicating "interesting with motion" is generated. Following that token, a control code 1 is generated indicating motion to the right. The video encoder therefore need not encode the data values 20 and 21 but merely needs to generate the interesting with motion token followed by the motion to the right control code. When the video encoder proceeds to the two data values block 14 and 15, the video encoder need not send

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the "interesting with motion" token but rather only sends the left control code 0. Similarly, when the video encoder proceeds to encode the two data value block 16 and 17, the video encoder only sends the left control code 0.

5 The control codes for octaves 0 and 1 do not denote motion per se but rather denote left or right location above a lower frequency interesting block of the moving edge. This results in the video encoder not having to encode any of the actual data values representing the moved edge in

10 the decomposition of Figure 43.

The one dimensional illustration of Figures 41, 42 and 43 is presented for ease of illustration and explanation. It is to be understood, however, that this method of indicating edge motion is used in conjunction

15 with the above described two dimensional wavelet decomposition such as the two dimensional wavelet decomposition illustrated in Figure 25. The video encoder searches for movement of the data values representing an edge only by searching the nearest neighboring blocks of

20 data values in the old frame. This method can be used to search many neighbors or a few neighbors depending on the application. The counter scheme described in connection with Figures 27 and 28 can be used to determine the locations of those neighboring blocks. Although the edge

25 motion illustrated in connection with Figures 41, 42, and 43 shows the very same data values being moved in the tree structure of the decomposition, it is to be understood that in practice the values of the data values representing the same edge may change slightly with the

30 movement of the edge. The video encoder takes this into account by judging corresponding data values using a motion data value threshold to determine if corresponding data values in fact do represent the same edge. By indicating edge motion and not sending the edge data

35 values themselves it is possible to both increase the compression and also improve the quality of the decompressed image.

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## SIX COEFFICIENT QUASI-DAUBECHIES FILTERS

The Daubechies six coefficient filters are defined by the six low pass filter coefficients, listed in the table below to 8 decimal places. The coefficients are also defined in terms of four constants,  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\epsilon$ , where  $\alpha = 0.10588942$ ,  $\beta = -0.54609641$ ,  $\gamma = 2.4254972$  and  $\epsilon = 3.0059769$ .

	Daubechies coefficients	Alternative representation	Normalized coefficients	Converted Coefficients
a	0.33267055	$1/\epsilon$	0.2352336	$\frac{30}{128}$
b	0.80689151	$\gamma/\epsilon$	0.57055846	$\frac{73}{128}$
c	0.45987750	$-\beta(\alpha+\gamma)/\epsilon$	0.3251825	$\frac{41}{128}$
-d	-0.13501102	$\beta(1 - \alpha\gamma)/\epsilon$	-0.095467208	$\frac{-12}{128}$
-e	-0.08544127	$-\alpha\gamma/\epsilon$	-0.060416101	$\frac{-7}{128}$
f	0.03522629	$\alpha/\epsilon$	0.024908749	$\frac{3}{128}$

Table 4

The coefficients (a, b, c, -d, -e, f) sum to  $\sqrt{2}$ . The normalized coefficients sum to 1, which gives the filter the property of unity gain, which in terms of the alternative representation is equivalent to a change in the value of  $\epsilon$  to 4.2510934. These values can be approximated to any given precision by a set of fractions. In the example shown above, each of the normalized values has been multiplied by 128 and rounded appropriately, thus the coefficient a has been converted to  $\frac{30}{128}$ . Filtering is therefore possible using integer multiplications rather than floating point arithmetic. This greatly reduces implementation cost in terms of digital hardware gate count and computer software speed. The following equations show a single step in the filtering process, the outputs H and G being the low and high pass outputs, respectively:

$$H_1 = aD_0 + bD_1 + cD_2 - dD_3 - eD_4 + fD_5 \quad (\text{equ. } 72)$$



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$$G_1 = -fD_0 - eD_1 + dD_2 + cD_3 - bD_4 + aD_5 \quad (\text{equ. 73})$$

$H_1$  and  $G_1$  are calculated as follows. Each data value  $D$  is multiplied by the relevant integer numerator (30, 73, 41, 12, 7, 3) and summed as shown. The values of  $H$  and  $G$  are found by dividing the summations by the constant 128. Because 128 is an integer power of 2, the division operation requires little digital hardware to implement and only simple arithmetic shift operations to implement in software. The filters  $H$  and  $G$  are quasi-perfect reconstruction filters:

$$a+b+c-d-e+f=1 \quad (\text{equ. 74})$$

$$-f-e+d+c-b+a=0 \quad (\text{equ. 75})$$

$$a+c-e=\frac{1}{2} \quad (\text{equ. 76})$$

$$f-d+b=\frac{1}{2} \quad (\text{equ. 77})$$

Equation 74 guarantees unity gain. Equation 75 guarantees that the high pass filter will generate zero for a constant input signal. Equations 76 and 77 guarantee that an original signal once transferred can be reconstructed exactly.

The following equations show a single step in the inverse transformation:

$$D_1 = 2(-eH_0 - bG_0 + cH_1 + dG_1 + aH_2 - fG_2) \quad (\text{equ. 78})$$

$$D_2 = 2(fH_0 + aG_0 - dH_1 + cG_1 + bH_2 - eG_2) \quad (\text{equ. 79})$$

As for the forward filtering process, the interleaved  $H$  and  $G$  data stream is multiplied by the relevant integer numerator and summed as shown. The output  $D$  data values are found by dividing the summations by the constant 64, which is also an integer power of 2.

To calculate the first and last  $H$  and  $G$  values, the filter equations must be altered such that values outside the boundaries of the data stream are not required. For example, if  $H_0$  is to be calculated using the six coefficient filter, the values  $D_1$  and  $D_2$  would be required. Because

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these values are not defined, a different filter is used at the beginning and end of the data stream. The new filters are determined such that the reconstruction process for the first and last two data values is possible. The following 5 pair of equations show the filter used to calculate the first H and G values:

$$H_0 = cD_0 - dD_1 - eD_2 + fD_3 \quad (\text{equ. 80})$$

$$G_0 = dD_0 + cD_1 - bD_2 + aD_3 \quad (\text{equ. 81})$$

The last H and G values are calculated with:

$$10 \quad H_3 = aD_1 + bD_2 + cD_4 - dD_5 \quad (\text{equ. 82})$$

$$G_3 = fD_1 - eD_2 + dD_4 + cD_5 \quad (\text{equ. 83})$$

In this case, these equations are equivalent to using the non-boundary equations with data values outside the data stream being equal to zero. The following inverse 15 transform boundary filters are used to reconstruct the first two and last two data values:

$$D_0 = 2 \left( \left( c - \frac{b}{\beta} \right) H_0 + \left( d + \frac{e}{\beta} \right) G_0 + aH_1 - fG_1 \right) \quad (\text{equ. 84})$$

$$D_1 = 2 \left( \left( \frac{a}{\beta} - d \right) H_0 + \left( c - \frac{f}{\beta} \right) G_0 + bH_1 - eG_1 \right) \quad (\text{equ. 85})$$

$$D_4 = 2 \left( -eH_1 - bG_1 + \left( c - \frac{f}{\beta} \right) H_3 + \left( d - \frac{a}{\beta} \right) G_3 \right) \quad (\text{equ. 86})$$

$$D_5 = 2 \left( fH_1 + aG_1 - \left( d + \frac{e}{\beta} \right) H_3 + \left( c - \frac{b}{\beta} \right) G_3 \right) \quad (\text{equ. 87})$$

#### INCREASING SOFTWARE DECOMPRESSION SPEED

A system is desired for compressing and decompressing video using dedicated digital hardware to compress and 20 using software to decompress. For example, in a video mail application one user uses a hardware compression expansion card for an IBM PC personal computer coupled to a video camera to record a video message in the form of a video message file. This compressed video message file is then 25 transmitted via electronic mail over a network such as a hardwired network of an office building. A recipient user receives the compressed video message file as he/she would receive a normal mail file and then uses the software to

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decompress the compressed video message file to retrieve the video mail. The video mail may be displayed on the monitor of the recipient's personal computer. It is desirable to be able to decompress in software because  
5 decompressing in software frees multiple recipients from purchasing relatively expensive hardware. Software for performing the decompression may, for example, be distributed free of charge to reduce the cost of the composite system.

10 In one prior art system, the Intel Indeo video compression system, a hardware compression expansion card compresses video and a software package is usable to decompress the compressed video. This system, however, only achieves a small compression ratio. Accordingly,  
15 video picture quality will not be able to be improved as standard personal computers increase in computing power and/or video bandwidth.

The specification above discloses a method and apparatus for compressing and decompressing video. The  
20 software decompression implementation written in the programming language C disclosed in Appendix A only decompresses at a few frames per second on a standard personal computer at the present date. A method capable of implementation in software which realizes faster  
25 decompression is therefore desirable.

A method for decompressing video described above is therefore modified to increase software execution speed. Although the  $b=19/32$ ,  $a=11/32$ ,  $c=5/32$  and  $d=3/32$  coefficients used to realize the high and low pass forward  
30 transform perfect reconstruction digital filters are used by dedicated hardware to compress in accordance with an above described method, the coefficients  $b=5/8$ ,  $a=3/8$ ,  $c=1/8$  and  $d=1/8$  are used to decompress in software on a digital computer. The coefficients are determined as shown  
35 in the table below.

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$$\begin{aligned}
 a &= \frac{1+\sqrt{3}}{8} = .3415(8) = 2.732 = \frac{3}{8} \\
 b &= \frac{3+\sqrt{3}}{8} = .5915(8) = 4.732 = \frac{5}{8} \\
 c &= \frac{3-\sqrt{3}}{8} = .1585(8) = 1.268 = \frac{1}{8} \\
 d &= \frac{-1+\sqrt{3}}{8} = .0915(8) = 0.732 = \frac{1}{8}
 \end{aligned}$$

5

Table 5

An even start inverse transform digital filter in accordance with the present embodiment is:

$$D_0 = 4[(b-a)H_0 + (c-d)G_0] \quad (\text{equ. 88})$$

where, for example,  $D_0$  is a first inverse transformed data value indicative of a corresponding first data value of a row of the original image, and where  $H_0$  and  $G_0$  are first low and high pass component transformed data values of a row of a sub-band decomposition.

An odd end inverse transform digital filter in accordance with the present embodiment is:

$$D_1 = 4[(c+d)H_1 - (a+b)G_1] \quad (\text{equ. 89})$$

where, for example,  $D_1$  is a last inverse transformed data value indicative of a corresponding last data value of a row of the original image, and where  $H_1$  and  $G_1$  are last low and high pass component transformed data values of a row of a sub-band decomposition.

An odd interleaved inverse transform digital filter in accordance with the present embodiment is:

$$\frac{D(2x-1)}{2} = \frac{1}{8}H(x-1) - \frac{3}{8}G(x-1) + \frac{3}{8}H(x) + \frac{1}{8}G(x) \quad (\text{equ. 90})$$

25 An even interleaved inverse transform digital filter in accordance with the present embodiment is:

$$\frac{D(2x)}{2} = -\frac{1}{8}H(x-1) + \frac{3}{8}G(x-1) + \frac{3}{8}H(x) + \frac{1}{8}G(x) \quad (\text{equ. 91})$$

As indicated by equations 90 and 91, the odd and even interleaved inverse transform digital filters operable on

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the same H and G values of the sub-band decomposition but generate the odd and even inverse transformed data values in a row between the even start and odd end filters of equations 88 and 89.

5 Using the above even start, odd end, odd interleaved and even interleaved inverse transform digital filters, a frame rate of approximately 15 frames/second is realizable executing on a Macintosh Quadra personal computer having a 68040 microprocessor. Digital filters using the  
10 coefficients  $b=5/8$ ,  $a=3/8$ ,  $c=1/8$  and  $d=1/8$  may also be realized in dedicated digital hardware to reduce the cost of a dedicated hardware implementation where a slightly lower compression ratio is acceptable.

To further increase software decompression speed when  
15 decompressing video on a digital computer, only two octaves of inverse transform are performed on video which was previously compressed using three octaves of forward transform. This results in the low pass component of the octave 0 decomposition. The low pass component of the  
20 octave 0 decomposition is a non-aliased high quality quarter size decimated version of the original image. Rather than performing octave 0 of inverse transform, horizontal linear interpolation is used to expand each row of data values of the low pass component of the octave 0  
25 decomposition into twice the number of data values. To expand the number of rows, each row of interpolated data values is replicated once so that the total number of rows is doubled. In some embodiments, interpolation techniques other than linear interpolation are used to improve image  
30 quality. For example, spline interpolation or polynomial interpolation may be used.

To further increase software execution speed when decompressing video, luminance data values are decompressed using the digital filters of equations 88, 89, 90 and 91.  
35 The chrominance data values, on the other hand, are decompressed using even and odd interleaved reconstruction filters having a fewer number of coefficients than four.

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In one embodiments, two coefficient odd interleaved Haar and even interleaved Haar filters are used. The even interleaved Haar reconstruction filter is:

$$D_0 = (H_0 + G_0) \quad (\text{equ. 92})$$

5 The odd interleaved Haar reconstruction filter is:

$$D_1 = (H_0 - G_0) \quad (\text{equ. 93})$$

Because the above Haar filters each only have two coefficients, there is no boundary problem as is addressed in connection with an above-described method. Accordingly,  
10 another start inverse transform digital filter and another end inverse transform digital filter are not used.

To increase software execution speed still further when decompressing video, variable-length SEND and STILL\_SEND tokens are used. Data values are encoded using  
15 a Huffman code as disclosed above whereas tokens are generated in variable-length form and appear in this variable-length form in the compressed data stream. This allows decompression to be performed without first calculating flags.

20 Figure 44 shows variable-length tokens used for encoding and decoding in accordance with some embodiments of the present invention. Because transitions from SEND mode to STOP mode or from STILL\_SEND mode to STOP mode occur most frequently of the transitions indicated in  
25 Figure 44, the corresponding tokens consist of only one bit.

In general, if an area changes from white to black in two consecutive frames of a video sequence and if the encoder is in LPF\_SEND mode, then the difference between  
30 the corresponding data values after quantization will be much larger than 37. 37 is the maximum number encodable using the specific Huffman code set forth in connection with an above-described method. Because such a large

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change in data value cannot be encoded, an artifact will be generated in the decompressed image for any change in quantized data values exceeding 37. Accordingly, the Huffman code in the table below is used in accordance with one embodiment of the present invention.

	HUFFMAN CODE	qindex
	0	0
	1s1	$\pm 1$
	1s01	$\pm 2$
10	1s001	$\pm 3$
	1s0001	$\pm 4$
	1s00001	$\pm 5$
	1s000001	$\pm 6$
	1s0000001	$\pm 7$
15	1s0000000 ( $ qindex  - 8$ )	$\pm 8 \dots \pm 135$

Table 6

In Table 6 above, the value ( $|qindex| - 8$ ) is seven bits in length. The s in Table 6 above is a sign bit.

This embodiment is not limited to video mail applications and is not limited to systems using dedicated hardware to compress and software executing on a digital computer to decompress. Digital circuitry of a general purpose digital computer having a microprocessor may be used to decode and inverse transform a compressed image data stream. The coefficients  $5/8$ ,  $3/8$ ,  $1/8$  and  $1/8$  independent of sign may be the four coefficients of four coefficient high and low pass forward transform perfect reconstruction digital filters used to transform image data values into a sub-band decomposition.

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Although the present invention has been described by way of the above described specific embodiments, it will be understood that certain adaptations, modifications, rearrangements and combinations of various features of the specific embodiments may be practiced without departing from the scope of the invention. Filters other than the four coefficient quasi-Daubechies filters can be used. In some embodiments, six coefficient quasi-Daubechies filters are used. Embodiments of this invention may, for example, be practiced using a one-dimensional tree structure, a two-dimensional tree structure, or a three-dimensional tree structure. Rather than testing whether or not a two-by-two block of data values is interesting, blocks of other sizes may be used. Three-by-three blocks of data values may, for example, be tested. Blocks of different sizes may be used in different octaves of a decomposition. In certain embodiments, there are different types of interesting blocks. The use of tokens in combination with use of a tree structure of a decomposition to reduce the number of data values encoded may be extended to include other tokens having other meanings. The "interesting with motion" token is but one example. Tree structures may be used in numerous ways to estimate the activity of a frame for rate control purposes. Numerous boundary filters, thresholds, encoder and decoder modes, token schemes, tree traversing address generators, quantization schemes, Huffman-like codes, and rate control schemes will be apparent from the specific embodiments. The above-described specific embodiments are therefore described for instructional purposes only and are not intended to limit the invention as set forth in the appended claims.



DATA COMPRESSION AND DECOMPRESSION  
GREGORY KNOWLES AND ADRIAN S. LEWIS

M-2357 US  
APPENDIX A

source/Bits.c

```
/*
    Reading and writing bits from a file
*/

#include    "../include/xwave.h"
#include    "../include/Bits.h"

Bits  bopen(name,mode)

String name, mode;

{
    Bits  bits=(Bits)MALLOC(sizeof(BitsRec));

    if((bits->fp=fopen(name,mode))==(FILE*)0)Eprintf("Failed to open binary
file\n");    /*change*/
    bits->bufsize=0;    /*new*/
    bits->buf=(unsigned char)0;    /*new*/
    return(bits);
}

void  bclose(bits)

Bits  bits;

{
    if(fclos(bits->fp)!=0) Eprintf("Failed to close binary file\n"); /*was:
fclos(bits->fp)*/
```

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```

        XlFree(bits);
    }

void bread(bytes,num,bits)

unsigned char    *bytes;
int    num;
Bits    bits;

{
    int    byte=0, bit=0,pull,b;

    bytes[byte]=0;
    while(num > 0) {
        if (bits->bufsize == 0) {
            pull=fgetc(bits->fp);
            if(pull == EOF)
            {
                /*printf("EOF\n"); Previously didn't check for
EOF:bits->buf=(unsigned char)fgetc(bits->fp)*/
                for(b=byte+1;b<num/8+1;b++)
                    bytes[b]=(unsigned char)0;
                return;
            }
            bits->buf=(unsigned char)pull;
            bits->bufsize=8;
        }

        bytes[byte]=((1&bits->buf)!=0)?bytes[byte]|(1<<bit):bytes[byte]&~(1<<bit);
        if (bit==7) { bit=0; byte++; bytes[byte]=0; } /* was bit==8 */
        else bit++;
        bits->buf=bits->buf>>1;
    }
}

```

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```
        bits->bufsize--;  
        num--;  
    }  
}  
  
void  bwrite(bytes,num.bits)  
  
unsigned char    *bytes;  
int    num;  
Bits    bits;  
  
{  
    int    byte=0, bit=0;  
    unsigned char    xfer;  
  
    while(num > 0) {  
        if (bit==0) {  
            xfer=bytes[byte++];
```

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source/Color.c

/\*

\* Color routines

\*/

#include "../include/xwave.h"

#define GAMMA 1.0/2.2

int

VisualClass[6] = {PseudoColor, DirectColor, TrueColor, StaticColor, GrayScale, StaticGray};

/\* Function Name: Range

\* Description: Range convert for RGB/YUV calculations

\* Arguments: old\_x - old value (0..old\_r-1)

\* old\_r - old range &lt; new\_r

\* new\_r - new range

\* Returns: old\_x scaled up to new range

\*/

int Range(old\_x, old\_r, new\_r)

int old\_x, old\_r, new\_r;

{

return((old\_x\*new\_r)/old\_r);

}

/\* Function Name: Gamma

\* Description: Range convert with Gamma correction for RGB/YUV calculations

\* Arguments: as Range +

\* factor - gamma correction factor

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\* Returns: old\_x gamma corrected and scaled up to new range

\*/

```
int Gamma(old_x,old_r,new_r,factor)
```

```
int old_x, old_r, new_r;
```

```
double factor;
```

```
{
    return((int)((double)new_r*pow((double)old_x/(double)old_r,factor)));
}
```

```
/* Function Name: Dither
```

\* Description: Range convert with dithering for RGB/YUV calculations

\* Arguments: levels - output range (0..levels-1)

\* pixel - pixel value (0..1 < < 8+precision-1)

\* x, y - dither location

\* precision - pixel range (0..1 < < 8+precision-1)

\* Returns: dithered value (0..levels-1)

\*/

```
int Dither(levels,pixel,x,y,precision)
```

```
int pixel, levels, x, y, precision;
```

```
{
    int bits=8+precision,
        pixlev=pixel*levels,
```

```
value=(pixlev >> bits)+((pixlev-(pixlev&(-1 << bits)))>> precision>global->dither[x
&15][y&15]?1:0);
```

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```

    return(value > = levels?levels-1:value);
}

/*  Function Name:    ColCvt
 *   Description:    Converts between RGB and YUV triples
 *   Arguments:      src - source triple
 *                   dst - destination triple
 *                   rgb_yuv - convert direction RGB->YUV True
 *                   max - range of data (max-1..-max)
 *   Returns:        alters dst.
 */

```

```
void ColCvt(src,dst,rgb_yuv,max)
```

```
short src[3], dst[3];
```

```
Boolean rgb_yuv;
```

```
int max;
```

```

{
    double    rgb_yuv_mat[2][3][3]={
        {0.299,0.587,0.114},
        {-0.169,-0.3316,0.5},
        {0.5,-0.4186,-0.0813}
    },{
        {1,0,1.4021},
        {1,-0.3441,-0.7142},
        {1,1.7718,0}
    }
};
int i, channel;

```

```
for(channel=0;channel<3;channel++) {
```

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```

        double      sum=0.0;

        for(i=0;i<3;i++)
            sum+=(double)(src[i])*rgb_yuv_mat[rgb_yuv?0:1][channel][i];
        dst[channel]=(int)sum<-max?-max:(int)sum>max-1?max-1:(short)sum;
    }
}

```

```

/*  Function Name:      CompositePixel
 *  Description:        Calculates pixel value from components
 *  Arguments:          frame - Frame to be drawn on
 *                      x, y - coordinate of pixel in data
 *                      X, Y - coordinate of pixel in display
 *  Returns:            pixel value in colormap
 */

```

```
int  CompositePixel(frame,x,y,X,Y)
```

```
Frame frame;
```

```
int    x, y, X, Y;
```

```

{
    Video vid=frame->video;
    int    channel=frame->channel, pixel, value=0;

    if (channel!=3) {
        pixel=(int)vid->data[channel][frame->frame][Address2(vid,channel,x,y)]+(128<<vid->precision);
        value=Dither(global->levels,pixel,X,Y,vid->precision);
    } else for(channel=0;channel<3;channel++) {
        int

```



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```
levels = vid->type == RGB?global->rgb_levels:global->yuv_levels[channel];
```

```
pixel = (int)vid->data[channel][frame->frame][Address(vid,channel,x,y)] + (128 < < vid->precision),
```

```
value = levels*value + Dither(levels,pixel,X,Y,vid->precision);
```

```
}
```

```
return(value);
```

```
}
```

```
void InitVisual()
```

```
{
```

```
Display *dpy = XtDisplay(global->toplevel);
```

```
int scrn = XDefaultScreen(dpy), class=0, depth=8, map, i, r, g, b, y, u, v;
```

```
String
```

```
VisualNames[6] = {"PseudoColor", "DirectColor", "TrueColor", "StaticColor", "GrayScale",  
"StaticGray"};
```

```
XColor color;
```

```
global->visinfo = (XVisualInfo *)MALLOC(sizeof(XVisualInfo));
```

```
while(depth > 0
```

```
&&!XMatchVisualInfo(dpy,scrn,depth,VisualClass[class],global->visinfo))
```

```
if (class == 5) {class=0; depth--;} else class++;
```

```
Dprintf("Visual: %s depth %d\n",VisualNames[class],depth);
```

```
global->palettes = (Palette)MALLOC(sizeof(PaletteRec));
```

```
strcpy(global->palettes->name,"Normal");
```

```
global->palettes->next = NULL;
```

```
global->no_pals = 1;
```

```
switch(global->visinfo->class) {
```

```
case TrueColor:
```

```
case DirectColor:
```

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```

case StaticColor:
case GrayScale:
    fprintf(stderr, "Unsupported visual type: %s\n", VisualNames[class]);
    exit();
    break;
case PseudoColor:
    global->levels = global->visinfo->colormap_size;
    global->rgb_levels = (int)pow(((double)global->levels, 1.0/3.0);
    for(map=0; map<2; map++) { /* rgb non-gamma and gamma maps */

global->cmaps[map] = XCreateColormap(dpy, XDefaultRootWindow(dpy), global->visinfo
->visual, AllocAll);

        for(r=0; r<global->rgb_levels; r++)
            for(g=0; g<global->rgb_levels; g++)
                for(b=0; b<global->rgb_levels; b++) {

color.pixel = (r*global->rgb_levels + g)*global->rgb_levels + b;

color.red = (map&1)?Gamma(r, global->rgb_levels, 65536, GAMMA):Range(r, global->rg
b_levels, 65536);

color.green = (map&1)?Gamma(g, global->rgb_levels, 65536, GAMMA):Range(g, global->
rgb_levels, 65536);

color.blue = (map&1)?Gamma(b, global->rgb_levels, 65536, GAMMA):Range(b, global->r
gb_levels, 65536);

color.flags = DoRed | DoGreen | DoBlue;

XStoreColor(dpy, global->cmaps[map], &color);

        }

color.pixel = global->levels-1;
color.red = 255 < < 8;

```

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```

        color.green=255 < < 8;
        color.blue=255 < < 8;
        color.flags=DoRed | DoGreen | DoBlue;
        XStoreColor(dpy,global->cmaps[map],&color);
    }
    for(map=2;map<4;map++) { /* mono non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(i=0;i<global->visinfo->colormap_size;i++) {
            color.pixel=i;

color.red=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels,6
5536);

color.green=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels
,65536);

color.blue=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels,
65536);

            color.flags=DoRed | DoGreen | DoBlue;
            XStoreColor(dpy,global->cmaps[map],&color);
        }
    }
    global->yuv_levels[0]=(int)pow((double)global->levels,1.0/2.0);
    global->yuv_levels[1]=(int)pow((double)global->levels,1.0/4.0);
    global->yuv_levels[2]=(int)pow((double)global->levels,1.0/4.0);
    for(map=4;map<6;map++) { /* yuv non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(y=0;y<global->yuv_levels[0];y++)

```

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```

        for(u=0;u < global->yuv_levels[1];u++)
            for(v=0;v < global->yuv_levels[2];v++) {
                short
src[3] = {(short)(Range(y,global->yuv_levels[0],65536)-32768),

(short)(Range(u,global->yuv_levels[1],65536)-32768),

(short)(Range(v,global->yuv_levels[2],65536)-32768)}, dst[3];

                ColCvt(src,dst,False,65536/2);

color.pixel=(y*global->yuv_levels[1]+u)*global->yuv_levels[2]+v;

color.red=(map&1)?Gamma((int)dst[0]+32768,65536,65536,GAMMA):(int)dst[0]+3276
8;

color.green=(map&1)?Gamma((int)dst[1]+32768,65536,65536,GAMMA):(int)dst[1]+32
768;

color.blue=(map&1)?Gamma((int)dst[2]+32768,65536,65536,GAMMA):(int)dst[2]+327
68;

                color.flags=DoRed | DoGreen | DoBlue;

XStoreColor(dpy,global->cmaps[map],&color);
            }
        color.pixel=global->levels-1;
        color.red=255<<8;
        color.green=255<<8;
        color.blue=255<<8;
        color.flags=DoRed | DoGreen | DoBlue;
        XStoreColor(dpy,global->cmaps[map],&color);
    }

```

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```

        global->palettes->mappings=NULL;
        break;
    case StaticGray:
        global->levels=1<<depth;
        for(i=0;i<6;i++) global->cmaps[i]=XDefaultColormap(dpy,scrn);
        color.pixel=0;
        XQueryColor(dpy,XDefaultColormap(dpy,scrn),&color);
        if (color.red==0 && color.green==0 && color.blue==0)
global->palettes->mappings=NULL;
        else {
            global->palettes->mappings=(Map)MALLOC(sizeof(MapRec));
            global->palettes->mappings->start=0;
            global->palettes->mappings->finish=global->levels-1;
            global->palettes->mappings->m=-1;
            global->palettes->mappings->c=global->levels-1;
            global->palettes->mappings->next=NULL;
        }
        break;
    }
}

```

Colormap    ChannelCmap(channel,type,gamma)

int    channel;

VideoFormat type;

Boolean    gamma;

{

Colormap    cmap;

if (channel!=3 || type==MONO) {

if (gamma) cmap=global->cmaps[global->cmaps[2]==NULL?3:2];

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```
        else cmap=global->cmaps[global->cmaps[3] == NULL?2:3];
    } else if (type == RGB) {
        if (gamma) cmap=global->cmaps[global->cmaps[0] == NULL?1:0];
        else cmap=global->cmaps[global->cmaps[1] == NULL?0:1];
    } else {
        if (gamma) cmap=global->cmaps[global->cmaps[4] == NULL?5:4];
        else cmap=global->cmaps[global->cmaps[5] == NULL?4:5];
    }
    return(cmap);
}
```

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## source/Convert.c

```
#include    "../include/xwave.h"

short  cu(c)

char  c;

{
    return((short)(c)^-128);
}

char  iuc(i)

short  i;

{
    static int    errors=0;
    if (i < -128 || i > 127) {
        if (errors == 99) {
            Dprintf("100 Conversion overflows\n");
            errors=0;
        } else errors++;
        i=(i < -128)?-128:127;
    }
    return((char)(i^128));
}
```

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## source/Convolve3.c

```

/*
    2D wavelet transform convolver (fast hardware emulation)
    New improved wavelet coeffs: 11 19 5 3
*/

#include    "../include/xwave.h"

/*    Function Name:    Round
 *    Description:    Rounding to a fixed number of bits, magnitude rounded down
 *    Arguments:    number - number to be rounded
 *                  bits - shifted bits lost from number
 *    Returns: rounded number
 */

short Round(number,bits)

int    number;
int    bits;

{
    if (bits == 0) return((short)number);
    else return((short)(number + (1 << bits-1) - (number < 0 ? 0 : 1) >> bits));
}

/*    Function Name:    Convolve
 *    Description:    Perform a wavelet convolution on image data
 *    Arguments:    data - data to be transformed
 *                  dirn - convolution direction

```



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```

*           size - size of image data
*           oct_src, oct_dst - initial and final octave numbers
*   Returns:   data altered
*/

```

```
void Convolve(data,dirn,size,oct_src,oct_dst)
```

```
short *data;
```

```
Boolean   dirn;
```

```
int   size[2], oct_src, oct_dst;
```

```
{
```

```
    int   tab[4][4], addr[4]={-1,-1,-1,-1}, index, mode, i, j, oct, orient,
area=size[0]*size[1];
```

```
    Boolean   fwd_rev=oct_src<oct_dst;
```

```
    int   windows[12][5]={
```

```
        {1,2,3,-4,2}, /* 0 - normal forward 0 */
```

```
        {4,-3,2,1,3}, /* 1 - normal forward 1 */
```

```
        {1,-2,3,4,2}, /* 2 - normal reverse 0 */
```

```
        {4,3,2,-1,3}, /* 3 - normal reverse 1 */
```

```
        {2,3,4,-4,3}, /* 4 - end forward 0 */
```

```
        {4,-4,3,2,4}, /* 5 - end forward 1 */
```

```
        {2,2,3,-4,2}, /* 6 - start forward 0 */
```

```
        {4,-3,2,2,3}, /* 7 - start forward 1 */
```

```
        {3,-4,-4,3,4}, /* 8 - break reverse end dirn==False*/
```

```
        {4,3,-3,-4,3}, /* 9 - break reverse start dirn==False */
```

```
        {-3,-4,4,3,4}, /* 10 - break reverse end dirn==True */
```

```
        {-4,3,3,-4,3}, /* 11 - break reverse start dirn==True */
```

```
    }, win[3];           /* 12 - no calculation */
```

```
    for(oct=oct_src;oct!=oct_dst;oct+=(fwd_rev?1:-1)) {
```

```
        long   shift=oct-(fwd_rev?0:1);
```

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```

for(orient=0;orient<2;orient++) {
    Boolean    x_y=fwd_rev==(orient==0);

for (index=0;index<(area>>(shift<<1));index++) {
    long    major, minor, value, valuex3, valuex11, valuex19, valuex5;

    major=index/(size[x_y?0:1]>>shift);
    minor=index-major*(size[x_y?0:1]>>shift);
    for(j=0;j<3;j++) win[j]=12;
    switch(minor) {
    case 0: break;
    case 1: if (!fwd_rev) win[0]=dirn?11:9; break;
    case 2: if (fwd_rev) { win[0]=6; win[1]=7; }; break;
    default:
        if (minor+1==size[x_y?0:1]>>shift) {
            if (fwd_rev) { win[0]=4; win[1]=5; }
            else { win[0]=2; win[1]=3; win[2]=dirn?10:8; }
        } else if (fwd_rev) {
            if ((1&minor)==0) { win[0]=0; win[1]=1; }
        } else {
            if ((1&minor)!=0) { win[0]=2; win[1]=3; }
        }
    }
    }
    addr[3&index]=(x_y?minor:major)+size[0]*(x_y?major:minor)<<shift;
    value=(im)data[addr[3&index]];

    valuex5=value+(value<<2);
    valuex3=value+(value<<1);
    valuex11=valuex3+(value<<3);
    valuex19=valuex3+(value<<4);
    tab[3&index][3]=fwd_rev || !dirn?valuex3:valuex19;
    tab[3&index][2]=fwd_rev || dirn?valuex5:valuex11;

```

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```

tab[3&index][1]=fwd_rev || !dirn?valuex19:valuex3;
tab[3&index][0]=fwd_rev || dirn?valuex11:valuex5;
for(j=0;j<3 && win[j]!=12;j++) {
    int    conv=0;

    for(i=0;i<4;i++) {
        int    wave=dirn?3-i:i;

        conv+=negif(0> windows[win[j]][wave],tab[3&index+abs(windows[win[j]][i])][wave]);
    }

    data[addr[3&index+windows[win[j]][4]]]=Round(conv,fwd_rev?5:win[j]>7?3:4);
}
}}}
}

```

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## source/Copy.c

```
/*
    Copy video, includes direct copy, differencing, LPF zero, LPF only, RGB-YUV
    conversion and gamma correction
*/

#include    "../include/xwave.h"
#include    "Copy.h"
extern int  Shift();
extern void ColCvt();

void CopyVideoCtrl(w,closure,call_data)

Widget      w;
caddr_t closure, call_data;

{
    CopyCtrl  ctrl=(CopyCtrl)closure;
    Video new=CopyHeader(ctrl->video).src=ctrl->video;
    int  frame, channel, i, x, y, X, Y, map[256];

    if (global->batch==NULL)
ctrl->mode=(int)XawToggleGetCurrent(ctrl->radioGroup);
    strcpy(new->name,ctrl->name);
    strcpy(new->files,new->name);
    switch(ctrl->mode) {
case 1:    Dprintf("Direct copy\n");
            new->UVsample[0]=ctrl->UVsample[0];
            new->UVsample[1]=ctrl->UVsample[1];
```

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```

        break;
    case 2:    Dprintf("Differences\n");
        break;
    case 3:    Dprintf("LPF zero\n");
        break;
    case 4:    Dprintf("LPF only\n");
        new->trans.type = TRANS_None;

new->size[0] = new->size[0] >> new->trans.wavelet.space[0];

new->size[1] = new->size[1] >> new->trans.wavelet.space[0];
        break;
    case 5:    Dprintf("RGB-YUV\n");
        new->type = new->type == YUV?RGB:YUV;
        new->UVsample[0] = 0;
        new->UVsample[1] = 0;
        break;
    case 6:    Dprintf("Gamma conversion\n");
        new->gamma = !new->gamma;
        for(i=0;i<256;i++)
map[i] = gamma(i,256,new->gamma?0.5:2.0);
        break;
}
if (new->disk == True) SaveHeader(new);
for(frame=0;frame<new->size[2];frame++) {
    GetFrame(src,frame);
    NewFrame(new,frame);
    switch(ctrl->mode) {
    case 1:
for(channel=0;channel<(new->type == MONO?1:3);channel++) {
        int    size = Size(new,channel,0)*Size(new,channel,1);

```

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```

        for(y=0;y < Size(new,channel,1);y++)
            for(x=0;x < Size(new,channel,0);x++)

new->data[channel][frame][x+Size(new,channel,0)*y]=src->data[channel][frame][Shift(
x,src->type==YUV &&
channel!=0?new->UVsample[0]-src->UVsample[0]:0)+Size(src,channel,0)*Shift(y,src-
>type==YUV && channel!=0?new->UVsample[1]-src->UVsample[1]:0)];
    }
    break;

    case 2:
for(channel=0;channel < (new->type==MONO?1:3);channel++) {
    int
size=Size(new,channel,0)*Size(new,channel,1);

        for(i=0;i < size;i++)

new->data[channel][frame][i]=src->data[channel][frame][i]-(frame==0?0:src->data[ch
annel][frame-1][i]);
    }
    break;

    case 3:
for(channel=0;channel < (new->type==MONO?1:3);channel++) {
    int
size=Size(new,channel,0)*Size(new,channel,1);

        for(i=0;i < size;i++) {
            x=i%Size(new,channel,0);

y=i/Size(new,channel,0);

            if
(x%(1 < < new->trans.wavelet.space[new->type==YUV && channel!=0?1:0])==0
&& y%(1 < < new->trans.wavelet.space[new->type==YUV &&
channel!=0?1:0])==0)

```

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```

new->data[channel][frame][i]=0;

                                else
new->data[channel][frame][i]=src->data[channel][frame][i];
                                }
                                }
                                break;

        case 4:
for(channel=0;channel<(new->type==MONO?1:3);channel++) {
                                int
size=Size(new,channel,0)*Size(new,channel,1);

                                for(i=0;i<size;i++) {
                                        x=i%Size(new,channel,0);
y=i/Size(new,channel,0);

new->data[channel][frame][i]=src->data[channel][frame][(x+(y<<new->trans.wavele
t.space[0])*Size(new,channel,0))<<new->trans.wavelet.space[0]];
                                }
                                }
                                break;

        case 5:    for(X=0;X<new->size[0];X++)
for(Y=0;Y<new->size[1];Y++) {

                                short  src_triple[3], dst_triple[3];

                                for(channel=0;channel<3;channel++)

src_triple[channel]=src->data[channel][frame][Address(src,channel,X,Y)];

ColCvt(src_triple,dst_triple,new->type==YUV,1<<7+new->precision);
                                for(channel=0;channel<3;channel++)
                                        new->data[channel][frame][Address(new,channel,X,Y)]=dst_triple[channel];
                                }

```

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```

        break;

        case 6:
            for(channel=0;channel < (new->type == MONO?1:3);channel++) {
                int
                size = Size(new,channel,0)*Size(new,channel,1);

                for(i=0;i < size;i++)
                    new->data[channel][frame][i] = map[src->data[channel][frame][i] + 128]-128;
            }
            break;
        }

        if (frame > 0) FreeFrame(src,frame-1);
        SaveFrame(new,frame);
        FreeFrame(new,frame);
    }
    FreeFrame(src,src->size[2]-1);
    new->next = global->videos;
    global->videos = new;
}

void BatchCopyCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    CopyCtrl  ctrl=(CopyCtrl)closure;

    if (ctrl->video == NULL)
        ctrl->video = FindVideo(ctrl->src_name,global->videos);
    CopyVideoCtrl(w,closure,call_data);
}

```



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```
CopyCtrl    InitCopyCtrl(name)
```

```
String name;
```

```
{
    CopyCtrl    ctrl=(CopyCtrl)MALLOC(sizeof(CopyCtrlRec));

    strcpy(ctrl->src_name,name);
    strcpy(ctrl->name,name);
    ctrl->mode=1;
    return(ctrl);
}
```

```
#define      COPY_ICONS      17
```

```
void  CopyVideo(w,closure,call_data)
```

```
Widget      w;
caddr_t      closure, call_data;
```

```
{
    Video video=(Video)closure;
    CopyCtrl    ctrl=InitCopyCtrl(video->name);
    NumInput    UVinputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    Message      msg=NewMessage(ctrl->name,NAME_LEN);
    XtCallbackRec  destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)UVinputs},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Widget      shell=ShellWidget("copy_video",w,SW_below,NULL,destroy_call),
```

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```

        form = FormatWidget("cpy_form".shell), widgets[COPY_ICONS];
FormItem    items[] = {
    {"cpy_cancel", "cancel", 0, 0, FW_icon, NULL},
    {"cpy_confirm", "confirm", 1, 0, FW_icon, NULL},
    {"cpy_title", "Copy a video", 2, 0, FW_label, NULL},
    {"cpy_vid_lab", "Video Name:", 0, 3, FW_label, NULL},
    {"cpy_text", NULL, 4, 3, FW_text, (String)msg},

    {"cpy_copy", "copy", 0, 5, FW_toggle, NULL},
    {"cpy_diff", "diff", 6, 5, FW_toggle, (String)6},
    {"cpy_lpf_zero", "lpf_zero", 7, 5, FW_toggle, (String)7},
    {"cpy_lpf_only", "lpf_only", 8, 5, FW_toggle, (String)8},
    {"cpy_color", "color_space", 9, 5, FW_toggle, (String)9},

    {"cpy_gamma", "gamma", 10, 5, FW_toggle, (String)10},
    {"cpy_UV0_int", NULL, 0, 6, FW_integer, (String)&UVinputs[0]},
    {"cpy_UV0_down", NULL, 12, 6, FW_down, (String)&UVinputs[0]},
    {"cpy_UV0_up", NULL, 13, 6, FW_up, (String)&UVinputs[0]},
    {"cpy_UV1_int", NULL, 0, 14, FW_integer, (String)&UVinputs[1]},

    {"cpy_UV1_down", NULL, 12, 14, FW_down, (String)&UVinputs[1]},
    {"cpy_UV1_up", NULL, 16, 14, FW_up, (String)&UVinputs[1]},
};

XtCallbackRec    callbacks[] = {
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {CopyVideoCtrl, (caddr_t)ctrl},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {NULL, NULL}, {NULL, NULL}, {NULL, NULL}, {NULL, NULL},
    {NULL, NULL}, {NULL, NULL},
    {NumIncDec, (caddr_t)&UVinputs[0]}, {NULL, NULL},

```

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```

        {NumIncDec,(caddr_t)&UVinputs[0]}, {NULL,NULL},
        {NumIncDec,(caddr_t)&UVinputs[1]}, {NULL,NULL},
        {NumIncDec,(caddr_t)&UVinputs[1]}, {NULL,NULL},
    };

    Dprintf("Copy Video\n");

    msg-> rows=1; msg-> cols=NAME_LEN;
    ctrl-> video=video;
    UVinputs[0].format="UV sub-sample X: %d";
    UVinputs[0].min=0;
    UVinputs[0].max=2;
    UVinputs[0].value= &ctrl-> UVsample[0];
    UVinputs[1].format="UV sub-sample Y: %d";
    UVinputs[1].min=0;
    UVinputs[1].max=2;
    UVinputs[1].value= &ctrl-> UVsample[1];

    ctrl-> UVsample[0]=video-> UVsample[0];
    ctrl-> UVsample[1]=video-> UVsample[1];
    FillForm(form,COPY_ICONS,items,widgets,callbacks);
    ctrl-> radioGroup=widgets[5];
    XtSetSensitive(widgets[6],video-> size[2]>1);
    XtSetSensitive(widgets[7],video-> trans.type!=TRANS_None);
    XtSetSensitive(widgets[8],video-> trans.type!=TRANS_None);
    XtSetSensitive(widgets[9],video-> type!=MONO);
    XtSetSensitive(widgets[10],video-> type!=YUV &&
video-> trans.type==TRANS_None);
    XtPopup(shell,XtGrabExclusive);
};

```

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source/Frame.c

```
/*
    Frame callback routines for Destroy
*/

#include    "../include/xwave.h"
#include    <X11/Xmu/SysUtil.h>
#include    <pwd.h>
extern void CvtIndex();
extern Palette FindPalette();
extern void SetSensitive();

typedef    struct {
    Frame frame;
    int    frame_number, frame_zoom, frame_palette, frame_channel;
} ExamCtrlRec, *ExamCtrl;

void    FrameDestroy(w,closure,call_data)

Widget    w;
caddr_t    closure, call_data;

{
    Frame frame=(Frame)closure;
    void    CleanUpPoints(), FrameDelete();

    Dprintf("FrameDestroy\n");
    frame->point->usage--;
    if (frame->msg!=NULL) {
```

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```
        frame->msg->shell=NULL;
        CloseMessage(NULL,(caddr_t)frame->msg,NULL);
    }
    if (frame->point->usage==0) CleanUpPoints(&global->points);
    XtPopdown(frame->shell);
    XtDestroyWidget(frame->shell);
    FrameDelete(&global->frames,frame);
}

void  CleanUpPoints(points)

Point  *points;

{
    Point  dummy=*points;

    if (dummy!=NULL) {
        if (dummy->usage<1) {
            *points=dummy->next;
            XtFree(dummy);
            CleanUpPoints(points);
        } else CleanUpPoints(&((*points)->next));
    };
}

void  FrameDelete(frames,frame)

Frame *frames, frame;

{
    if  (*frames!=NULL) {
        if (*frames==frame) {
```

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```

        int    number = frame->frame;

        frame->frame = -1;
        FreeFrame(frame->video.number);
        *frames = frame->next;
        XtFree(frame);
    } else FrameDelete(&(*frames)->next.frame);
}

}

void  ExamineCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    ExamCtrl  ctrl=(ExamCtrl)closure;
    Arg       args[1];

    if (ctrl->frame->frame!=ctrl->frame_number-ctrl->frame->video->start) {
        int    old_frame=ctrl->frame->frame;

        ctrl->frame->frame = ctrl->frame_number-ctrl->frame->video->start;
        FreeFrame(ctrl->frame->video,old_frame);
        GetFrame(ctrl->frame->video,ctrl->frame->frame);
    }

    ctrl->frame->zoom=ctrl->frame_zoom;
    ctrl->frame->palette=ctrl->frame_palette;
    ctrl->frame->channel=ctrl->frame_channel;
    XtSetArg(args[0],XtNbitmap,UpdateImage(ctrl->frame));
    XtSetValues(ctrl->frame->image_widget,args,ONE);

```

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```

XtSetArg(args[0],XtNcolormap,ChannelCmap(ctrl->frame->channel,ctrl->frame->vide
o->type,ctrl->frame->video->gamma));
    XtSetValues(ctrl->frame->shell,args,ONE);
    if (ctrl->frame->msg!=NULL) UpdateInfo(ctrl->frame);
}

```

```

#define      EXAM_ICONS      13

```

```

void  Examine(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{
    ExamCtrl  ctrl=(ExamCtrl)MALLOC(sizeof(ExamCtrlRec));
    NumInput  num_inputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    XtCallbackRec destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)num_inputs},
        {NULL,NULL},
    }, pal_call[2*global->no_pals];
    Widget      shell=ShellWidget("examine",w,SW_below,NULL,destroy_call),
        form=FormatWidget("exam_form",shell), widgets[EXAM_ICONS],
        pal_widgets[global->no_pals], pal_shell;
    Frame frame=(Frame)closure;
    FormItem  items[]={
        {"exam_cancel","cancel",0,0,FW_icon,NULL},
        {"exam_confirm","confirm",1,0,FW_icon,NULL},
        {"exam_label","Examine",2,0,FW_label,NULL},
        {"exam_ch_lab","Channel :",0,3,FW_label,NULL},
        {"exam_ch_btn",ChannelName[frame->video->type][frame->channel],4,3,FW_button,"

```

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```

exam_cng_ch"},
    {"exam_pal_lab","Palene :".0,4,FW_label,NULL},

{"exam_pal_btn",FindPalene(global->palenes,frame->palene)->name,4,4,FW_button,"
exam_cng_pal"},
    {"exam_z_int",NULL,0,6,FW_integer,(String)&num_inputs[0]},
    {"exam_z_down",NULL,8,6,FW_down,(String)&num_inputs[0]},
    {"exam_z_up",NULL,9,6,FW_up,(String)&num_inputs[0]},
    {"exam_zoom_int",NULL,0,8,FW_integer,(String)&num_inputs[1]},
    {"exam_zoom_down",NULL,8,8,FW_down,(String)&num_inputs[1]},
    {"exam_zoom_up",NULL,12,8,FW_up,(String)&num_inputs[1]},
};

MenuItem    pal_menu[global->no_pals];
XtCallbackRec    callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {ExamineCtrl,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[1]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[1]}, {NULL,NULL},
};

int    i, width=0;
Palette    pal=global->palettes;
XFontStruct    *font;
Arg    args[1];
caddr_t    dummy[global->no_pals], dummy2[global->no_pals]; /*
gcc-mc68020 bug avoidance */

Dprintf("Examine\n");

```



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```
ctrl->frame = frame;
ctrl->frame_number = frame->frame + frame->video->start;
ctrl->frame_zoom = frame->zoom;
ctrl->frame_palette = frame->palette;
ctrl->frame_channel = frame->channel;
num_inputs[0].format = "Frame: %03d";
num_inputs[0].max = frame->video->start + frame->video->size[2]-1;
num_inputs[0].min = frame->video->start;
num_inputs[0].value = &ctrl->frame_number;
num_inputs[1].format = "Zoom: %d";
num_inputs[1].max = 4;
num_inputs[1].min = 0;
num_inputs[1].value = &ctrl->frame_zoom;
```

```
FillForm(form, EXAM_ICONS, items, widgets, callbacks);
```

```
font = FindFont(widgets[6]);
for(i=0; pal != NULL; pal = pal->next, i++) {
    pal_menu[i].name = pal->name;
    pal_menu[i].widgetClass = smeBSBObjectClass;
    pal_menu[i].label = pal->name;
    pal_menu[i].hook = NULL;
    pal_call[i*2].callback = SimpleMenu;
    pal_call[i*2].closure = (caddr_t)&ctrl->frame_palette;
    pal_call[i*2+1].callback = NULL;
    pal_call[i*2+1].closure = NULL;
    width = TextWidth(width, pal->name, font);
}
pal_shell = ShellWidget("exam_cng_pal", shell, SW_menu, NULL, NULL);
FillMenu(pal_shell, global->no_pals, pal_menu, pal_widgets, pal_call);
XtSetArg(args[0], XtNwidth, 2 + width);
XtSetValues(widgets[6], args, ONE);
```

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```

    if (frame->video->type == MONO) XtSetSensitive(widgets[4],False);
    else {
        MenuItem    ch_menu[4];
        Widget
ch_shell=ShellWidget("exam_cng_ch",shell,SW_menu,NULL,NULL), ch_widgets[4];
        XtCallbackRec    ch_call[8];

        font=FindFont(widgets[4]);
        width=0;
        for(i=0;i<4;i++) {
            ch_menu[i].name=ChannelName[frame->video->type][i];
            ch_menu[i].widgetClass=smeBSBObjectClass;
            ch_menu[i].label=ChannelName[frame->video->type][i];
            ch_menu[i].hook=(caddr_t)&ctrl->frame_channel;
            ch_call[i*2].callback=SimpleMenu;
            ch_call[i*2].closure=(caddr_t)&ctrl->frame_channel;
            ch_call[i*2+1].callback=NULL;
            ch_call[i*2+1].closure=NULL;

width=TextWidth(width,ChannelName[frame->video->type][i],font);
        }
        FillMenu(ch_shell,4,ch_menu,ch_widgets,ch_call);
        XtSetArg(args[0],XtNwidth,2+width);
        XtSetValues(widgets[4],args,ONE);
    }
    XtPopup(shell,XtGrabExclusive);
}

void  FramePointYN(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

```

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```

{
    Frame  frame = (Frame)closure;
    Arg    args[1];
    Pixmap pixmap;
    Display *dpy = XtDisplay(global->toplevel);
    Icon   point_y = FindIcon("point_y"),
           point_n = FindIcon("point_n");

    Dprintf("FramePointYN\n");
    frame->point_switch = !frame->point_switch;
    XtSetSensitive(frame->image_widget, frame->point_switch);
    XtSetArg(args[0], XtNbitmap, (frame->point_switch?point_y:point_n)->pixmap);
    XtSetValues(w, args, ONE);
    XtSetArg(args[0], XtNbitmap, &pixmap);
    XtGetValues(frame->image_widget, args, ONE);
    UpdatePoint(dpy, frame, pixmap);
    XtSetArg(args[0], XtNbitmap, pixmap);
    XtSetValues(frame->image_widget, args, ONE);
    if (frame->msg != NULL) UpdateInfo(frame);
}

```

```

void  NewPoint(w, closure, call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

```

```

{
    Frame frame = (Frame)closure;
    Video vid = frame->video;
    void  UpdateFrames();
    int   *posn = (int *)call_data,
    channel = frame->channel == 3?0:frame->channel;

```

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```

    posn[0] = posn[0] >> frame->zoom; posn[1] = posn[1] >> frame->zoom;
    if (vid->trans.type == TRANS_Wave) {
        int    octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0?1:0], oct;

CvtIndex(posn[0], posn[1], Size(vid.channel, 0), Size(vid.channel, 1), octs, &posn[0], &posn[1]
, &oct);
    }
    if (vid->type == YUV && channel != 0) {
        posn[0] = posn[0] << vid->UVsample[0];
        posn[1] = posn[1] << vid->UVsample[1];
    }
    Dprintf("NewPoint %d %d previous %d
%d\n", posn[0], posn[1], frame->point->location[0], frame->point->location[1]);
    if (posn[0] != frame->point->location[0] ||
posn[1] != frame->point->location[1]) {
        UpdateFrames(global->frames, frame->point, False);
        frame->point->location[0] = posn[0];
        frame->point->location[1] = posn[1];
        UpdateFrames(global->frames, frame->point, True);
    } else Dprintf("No movement\n");
}

void  UpdateFrames(frame, point, update)

Frame frame;
Point point;
Boolean    update;

{
    Arg    args[1];

```

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```

    if (frame!=NULL) {
        if (point == frame->point && frame->point_switch == True) {
            Pixmap      pixmap;
            Display      *dpy=XtDisplay(global->toplevel);

            XtSetArg(args[0],XtNbitmap,&pixmap);
            XtGetValues(frame->image_widget,args,ONE);
            UpdatePoint(dpy,frame,pixmap);
            if (update == True) {
                XtSetArg(args[0],XtNbitmap,pixmap);
                XtSetValues(frame->image_widget,args,ONE);
                if (frame->msg!=NULL) UpdateInfo(frame);
            }
        }
        UpdateFrames(frame->next,point,update);
    }
}

```

```

void  CloseInfo(w,closure,call_data)

```

```

Widget      w;
caddr_t      closure, call_data;

```

```

{
    Frame frame=(Frame)closure;

    frame->msg=NULL;
}

```

```

#define      INFO_ICONS      2

```

```

void  FrameInfo(w,closure,call_data)

```

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```

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    Message    msg = NewMessage(NULL,1000);
    XtCallbackRec    callbacks[]={
        {SetSensitive,(caddr_t)w},
        {CloseInfo,(caddr_t)frame},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Dprintf("FrameInfo\n");
    frame->msg=msg;
    UpdateInfo(frame);
    TextSize(msg);
    MessageWindow(w,msg,frame->video->name,True,callbacks);
    XtSetSensitive(w,False);
}

```

```

void  FrameMerge(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    void  MergePoints();
    Arg    args[1];

    Dprintf("FrameMerge\n");
    MergePoints(global->frames.frame);
}

```

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}

```
void MergePoints(frame_search,frame_found)
```

```
Frame frame_search, frame_found;
```

{

```
Arg    args[1];
```

```
if (frame_search!=NULL) {
```

```
    if (NULL==XawToggleGetCurrent(frame_search->point_merge_widget)
```

```
|| frame_search==frame_found)
```

```
        MergePoints(frame_search->next,frame_found);
```

```
    else {
```

```
        Pixmap    pixmap;
```

```
        Display    *dpy=XtDisplay(global->toplevel);
```

```
        XtSetArg(args[0],XtNbitmap,&pixmap);
```

```
        XtGetValues(frame_found->image_widget,args,ONE);
```

```
        if (frame_found->point_switch==True)
```

```
UpdatePoint(dpy,frame_found,pixmap);
```

```
        frame_search->point->usage++;
```

```
        frame_found->point->usage--;
```

```
        if (frame_found->point->usage==0)
```

```
CleanUpPoints(&global->points);
```

```
        frame_found->point=frame_search->point;
```

```
        if (frame_found->point_switch==True) {
```

```
            UpdatePoint(dpy,frame_found,pixmap);
```

```
            XtSetArg(args[0],XtNbitmap,pixmap);
```

```
            XtSetValues(frame_found->image_widget,args,ONE);
```

```
        }
```

```
        if (frame_found->msg!=NULL) UpdateInfo(frame_found);
```

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```

        XawToggleUnsetCurrent(frame_search->point_merge_widget);
        XawToggleUnsetCurrent(frame_found->point_merge_widget);
    }

}

#define    POST_DIR    "postscript"

void    PostScript(w,closure,call_data)

Widget    w;
caddr_t    closure, call_data;

{
    Frame frame=(Frame)closure;
    Video video=frame->video;
    FILE *fp, *fopen();
    char    file_name[STRLEN], hostname[STRLEN];
    int    x, y, width=Size(video,frame->channel,0),
height=Size(video,frame->channel,1);
    struct passwd *pswd;
    long    clock;

    Dprintf("PostScript\n");
    sprintf(file_name,"%s%s/%s.ps\0",global->home,POST_DIR,video->name);
    fp=fopen(file_name,"w");
    fprintf(fp,"% %!PS-Adobe-1.0\n");
    pswd = getpwuid (getuid ());
    (void) XmuGetHostname (hostname, sizeof hostname);
    fprintf(fp,"% % % %Creator: %s:%s (%s)\n", hostname,pswd->pw_name,
pswd->pw_gecos);
    fprintf(fp,"% % % %Title: %s\n",video->name);

```



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```

    fprintf(fp, " % % % %BoundingBox: 0 0 %d %d\n", width, height);
    fprintf(fp, " % % % %CreationDate: %s", (time (&clock), ctime (&clock)));
    fprintf(fp, " % % % %EndComments\n");
    fprintf(fp, " %d %d scale\n", width, height);
    fprintf(fp, " %d %d 8 image_print\n", width, height);
    GetFrame(video, frame-> frame);
    for(y=0; y < height; y++) {
        for(x=0; x < width; x++) {
            int    X, Y, oct, data;

            if (video-> trans.type == TRANS_Wave) {

CvIndex(x, y, width, height, video-> trans.wavelet.space[0], &X, &Y, &oct);

            data=128+Round(video-> data[frame-> channel%3][frame-> frame][Y*video-> size[0]+
X]*(oct==video-> trans.wavelet.space[0]?1:4), video-> precision);
                } else
            data=128+Round(video-> data[frame-> channel%3][frame-> frame][y*video-> size[0]+
x], video-> precision);
                fprintf(fp, " %02x", data < 0?0:data > 255?255:data);
            }
            fprintf(fp, "\n");
        }
        FreeFrame(video, frame-> frame);
        fclose(fp);
    }

void  Spectrum(w, closure, call_data)

Widget      w;
caddr_t     closure, call_data;

```

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```

{
    Frame frame=(Frame)closure;
    Display      *dpy=XtDisplay(global->toplevel);
    XColor       xcolor[2], falsecolor;
    int          i;
    Colormap
cmap=ChannelCmap(frame->channel,frame->video->type,frame->video->gamma);

    Dprintf("Spectrum\n");
    falsecolor.flags=DoRed|DoGreen|DoBlue;
    XSynchronize(dpy,True);
    for(i=0;i<2+global->levels;i++) {
        if (i>1) XStoreColor(dpy,cmap,&xcolor[i&1]); /* Restore old color */
        if (i<global->levels) {
            xcolor[i&1].pixel=i;
            XQueryColor(dpy,cmap,&xcolor[i&1]);
            falsecolor.pixel=i;
            falsecolor.red=xcolor[i&1].red+32512;
            falsecolor.green=xcolor[i&1].green+32512;
            falsecolor.blue=xcolor[i&1].blue+32512;
            XStoreColor(dpy,cmap,&>falsecolor);
        }
    }
    XSynchronize(dpy,False);
}

```

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source/icon3.c

```
/*
    Create Icons/Menus and set Callbacks
*/

#include    "../include/xwave.h"

/*    Function Name:    FindIcon
 *    Description:    Finds IconRec entry from name in global icon array
 *    Arguments:    icon_name - name of icon bitmap
 *    Returns:    pointer to IconRec with the same name as icon_name
 */

Icon FindIcon(icon_name)

String icon_name;

{
    int    i;
    Icon    icon=NULL;

    for (i=0;i<global->no_icons;i++)
        if (!strcmp(global->icons[i].name,icon_name)) icon=&global->icons[i];
    return(icon);
}

void FillForm(parent,number,items,widgets,callbacks)

int    number;
```

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```

FormItem    items[];
Widget      parent, widgets[];
XtCallbackRec  callbacks[];

{

    Arg    args[10];
    int    i, call_i=0;

    for(i=0;i<number;i++) {
        int    argc=0, *view=(int *)items[i].hook;
        char    text[STRLEN];
        float    top;
        NumInput    num=(NumInput)items[i].hook;
        FloatInput    flt=(FloatInput)items[i].hook;
        Message    msg=(Message)items[i].hook;
        WidgetClass
class[15] = {labelWidgetClass,commandWidgetClass,commandWidgetClass,asciiTextWidge
tClass,

menuBunonWidgetClass,menuBunonWidgetClass,viewportWidgetClass,toggleWidgetClass

commandWidgetClass,commandWidgetClass,commandWidgetClass,labelWidgetClass,
scrollbarWidgetClass,labelWidgetClass,formWidgetClass};

        Boolean

call[15] = {False,True,True,False,False,False,False,True,True,True,True,False,False,Fals
e,False};

        if (items[i].fromHoriz!=0) {
            XtSetArg(args[argc],XtNfromHoriz,widgets[items[i].fromHoriz-1]);
            argc++;
        }
    }
}

```

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```

        if (items[i].fromVert!=0) {
            XtSetArg(args[argc],XtNfromVert,widgets[items[i].fromVert-1]);
argc ++;
        }
        switch(items[i].type) { /* Initialise contents */
        case FW_yn:
            items[i].contents=*(Boolean *)items[i].hook?"confirm":"cancel";
            break;
        case FW_up:
            items[i].contents="up";
            break;
        case FW_down:
            items[i].contents="down";
            break;
        case FW_integer:
            sprintf(text,num->format,*num->value);
            items[i].contents=text;
            break;
        case FW_float:
            sprintf(text,flt->format,*flt->value);
            items[i].contents=text;
            break;
        }
        switch(items[i].type) { /* Set contents */
        case FW_label: case FW_command: case FW_button: case FW_integer:
        case FW_float:
            XtSetArg(args[argc],XtNlabel,items[i].contents); argc ++;
            break;
        case FW_down: case FW_up: case FW_yn: case FW_toggle: case
FW_icon: case FW_icon_button: {
            Icon    icon=FindIcon(items[i].contents);

```

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```

        if (icon == NULL) {
            XtSetArg(args[argc], XtNlabel.items[i].contents); argc++;
        } else {
            XtSetArg(args[argc], XtNbixmap, icon->pixmap); argc++;
            XtSetArg(args[argc], XtNheight, icon->height+2); argc++;
            XtSetArg(args[argc], XtNwidth, icon->width+2); argc++;
        }
        } break;
    }

    switch(items[i].type) { /* Individual set-ups */
    case FW_text:
        XtSetArg(args[argc], XtNstring, msg->info.ptr); argc++;
        XtSetArg(args[argc], XtNeditType, msg->edit); argc++;
        XtSetArg(args[argc], XtNuseStringInPlace, True); argc++;
        XtSetArg(args[argc], XtNlength, msg->size); argc++;
        break;
    case FW_button: case FW_icon_button:
        XtSetArg(args[argc], XtNmenuName, (String)items[i].hook);
        argc++;
        break;
    case FW_toggle:
        if ((int)items[i].hook == 0) {
            XtSetArg(args[argc], XtNradioData, 1); argc++;
        } else {
            caddr_t radioData;
            Arg      radioargs[1];
            Widget    radioGroup = widgets[(int)items[i].hook-1];

            XtSetArg(radioargs[0], XtNradioData, &radioData);
            XtGetValues(radioGroup, radioargs, ONE);

            XtSetArg(args[argc], XtNradioData, (caddr_t)((int)radioData+1)); argc++;

```

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```

        XtSetArg(args[argc],XtNradioGroup,radioGroup); argc++;
    }
    break;
case FW_scroll:
    top=(float)(*flt->value-flt->min)/(flt->max-flt->min);
    XtSetArg(args[argc],XtNtopOfThumb,&top); argc++;
    XtSetArg(args[argc],XtNjumpProc,&callbacks[call_i]); argc++;
    while(callbacks[call_i].callback!=NULL) call_i++;
    call_i++;
    break;
case FW_view:
    if (view!=NULL) {
        XtSetArg(args[argc],XtNwidth,view[0]); argc++;
        XtSetArg(args[argc],XtNheight,view[1]); argc++;
    }
    break;
}

widgets[i]=XtCreateManagedWidget(items[i].name,class[(int)items[i].type],parent,args,argc);

switch(items[i].type) { /* Post processing */
case FW_toggle:
    if (items[i].hook==NULL) { /* Avoids Xaw bug */
        XtSetArg(args[0],XtNradioGroup,widgets[i]);
        XtSetValues(widgets[i],args,ONE);
    }
    break;
case FW_text: {
    XFontStruct *font;
    Arg    text_args[1];

    msg->widget=widgets[i];

```

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```

XawTextDisplayCaret(msg->widget,msg->edit!=XawtextRead);
XtSetArg(text_args[0],XtNfont,&font);
XtGetValues(widgets[i],text_args,ONE);
argc=0;
if (msg->edit==XawtextRead && msg->info.ptr[0]!='\0')
XtSetArg(args[argc],XtNwidth,4+TextWidth(0,msg->info.ptr,font));
else
XtSetArg(args[argc],XtNwidth,4+msg->cols*(font->max_bounds.width+font->min_bo
unds.width)/2);
argc++;

XtSetArg(args[argc],XtNheight,1+msg->rows*(font->max_bounds.ascent+font->max_
bounds.descent)); argc++;
XtSetValues(widgets[i],args,argc);
} break;
case FW_button:

XtOverrideTranslations(widgets[i],XtParseTranslationTable("<BtnDown>: reset()
NameButton() PopupMenu()"));
break;
case FW_down:
if (*num->value==num->min) XtSetSensitive(widgets[i],False);
num->widgets[0]=widgets[i];
break;
case FW_up:
if (*num->value==num->max) XtSetSensitive(widgets[i],False);
num->widgets[1]=widgets[i];
break;
case FW_integer:
num->widgets[2]=widgets[i];
break;
case FW_scroll:

```



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```

        flt->widgets[1]=widgets[i];
        XawScrollbarSetThumb(widgets[i],top,0.05);
        break;
    case FW_float:
        flt->widgets[0]=widgets[i];
        break;
    }
    if (call[(int)items[i].type]) { /* Add Callbacks */
        if (callbacks[call_i].callback!=NULL)
            XtAddCallbacks(widgets[i],XtNcallback,&callbacks[call_i]);
        while(callbacks[call_i].callback!=NULL) call_i++;
        call_i++;
    }
}
}

```

```
Widget      ShellWidget(name,parent,type,cmap,callbacks)
```

```
String name;
```

```
Widget      parent;
```

```
ShellWidgetType type;
```

```
Colormap    cmap;
```

```
XtCallbackRec callbacks[];
```

```
{
```

```
Widget      shell;
```

```
Arg  args[3];
```

```
Position    x, y;
```

```
Dimension    height=-2;
```

```
int  argc=0;
```

```
WidgetClass
```

```
class[] = {transientShellWidgetClass,transientShellWidgetClass,topLevelShellWidgetClass,p
```

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```
ullRightMenuWidgetClass};
```

```

    if (type == SW_below || type == SW_over) {
        XtTranslateCoords(parent,0,0,&x,&y);
        if (type == SW_below) {
            XtSetArg(args[0],XtNheight,&height);
            XtGetValues(parent,args,ONE);
        }
        XtSetArg(args[argc],XtNx,x); argc++;
        XtSetArg(args[argc],XtNy,y+height+2); argc++;
    }
    if (cmap != NULL) {
        XtSetArg(args[argc],XtNcolormap,cmap); argc++;
    }
    shell = XtCreatePopupShell(name,class[type],parent,args,argc);
    if (callbacks != NULL) XtAddCallbacks(shell,XtNdestroyCallback,callbacks);
    return(shell);
}

```

```
Widget      FormatWidget(name,parent)
```

```
String name;
```

```
Widget      parent;
```

```

{
    return(XtCreateManagedWidget(name,formWidgetClass,parent,NULL,ZERO));
}

```

```
void  FillMenu(parent,number,items,widgets,callbacks)
```

```
int    number;
```

```
MenuItem  items[];
```

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```
Widget      parent, widgets[];
XtCallbackRec  callbacks[];
```

```
{
    Arg  args[4];
    int  i, call_i=0;
    Icon icon=FindIcon("right");

    for(i=0;i<number;i++) {
        int  argc=0;

        XtSetArg(args[argc],XtNlabel,items[i].label); argc++;
        if (items[i].widgetClass == smeBSBprObjectClass) {
            XtSetArg(args[argc],XtNmenuName,items[i].hook); argc++;
            XtSetArg(args[argc],XtNrightMargin,4+icon->width); argc++;
            XtSetArg(args[argc],XtNrightBitmap,icon->pixmap); argc++;
        }

        widgets[i]=XtCreateManagedWidget(items[i].name,items[i].widgetClass,parent,args,argc)
        ;

        if (items[i].widgetClass == smeBSBObjectClass) { /* Add Callbacks */
            XtAddCallbacks(widgets[i],XtNcallback,&callbacks[call_i]);
            while(callbacks[call_i].callback!=NULL) call_i++;
            call_i++;
        }
    }
}
```

```
void SimpleMenu(w,closure,call_data)
```

```
Widget      w;
caddr_t     closure, call_data;
```

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```

{
    int      *hook=(int *)closure, no_child, child, argc=0;
    Widget      menu=XtParent(w), button;
    WidgetList  children;
    char      *label;
    Arg      args[3];

    XtSetArg(args[argc],XtNlabel,&label); argc++;
    XtGetValues(w,args,argc); argc=0;
    XtSetArg(args[argc],XtNchildren,&children); argc++;
    XtSetArg(args[argc],XtNnumChildren,&no_child); argc++;
    XtSetArg(args[argc],XtNbutton,&button); argc++;
    XtGetValues(menu,args,argc); argc=0;
    for(child=0;children[child]!=w && child<no_child;) child++;
    if (w!=children[child]) Eprintf("SimpleMenu: menu error\n");
    *hook=child;
    XtSetArg(args[argc],XtNlabel,label); argc++;
    XtSetValues(button,args,argc);
}

```

```

void NumIncDec(w,closure,call_data)

```

```

Widget      w;
caddr_t      closure, call_data;

```

```

{
    NumInput  data=(NumInput)closure;
    Arg      args[1];
    char      text[STRLEN];

    *data->value += (w==data->widgets[0])?-1:1;
    sprintf(text,data->format,*data->value);

```

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```

    if (data->min == *data->value) XtSetSensitive(data->widgets[0],False);
    else XtSetSensitive(data->widgets[0],True);
    if (data->max == *data->value) XtSetSensitive(data->widgets[1],False);
    else XtSetSensitive(data->widgets[1],True);
    XtSetArg(args[0],XtNlabel,text);
    XtSetValues(data->widgets[2],args,ONE);
}

```

```

void FloatIncDec(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

{
    FloatInput data=(FloatInput)closure;
    Arg  args[1];
    char text[STRLEN];
    float percent=*(float *)call_data;

    *data->value = data->min + (double)percent*(data->max-data->min);
    sprintf(text,data->format,*data->value);
    XtSetArg(args[0],XtNlabel,text);
    XtSetValues(data->widgets[0],args,ONE);
}

```

```

/*  Function Name:      ChangeYN
 *
 *  Description:  Toggle YN widget state
 *
 *  Arguments:   w - toggling widget
 *
 *                  closure - pointer to boolean state
 *
 *                  call_data - not used
 *
 *  Returns:      none.
 */

```

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```
void  ChangeYN(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Boolean      *bool=(Boolean *)closure;
```

```
    Icon   icon=FindIcon((*bool != True)?"confirm":"cancel");
```

```
    Arg     args[4];
```

```
    int     argc=0;
```

```
    *bool = ! *bool;
```

```
    XtSetArg(args[argc],XtNbitmap,icon->pixmap); argc ++;
```

```
    XtSetArg(args[argc],XtNheight,icon->height+2); argc ++;
```

```
    XtSetArg(args[argc],XtNwidth,icon->width+2); argc ++;
```

```
    XtSetValues(w,args,argc);
```

```
}
```

```
int  TextWidth(max,text,font)
```

```
int   max;
```

```
String text;
```

```
XFontStruct *font;
```

```
{
```

```
    int   i=0, j;
```

```
    while(text[i]!='\0') {
```

```
        int   width;
```

```
        for(j=0;text[i+j]!='\0' && text[i+j]!='\n';) j ++;
```

```
        width=XTextWidth(font,&text[i],j);
```

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max = max > width?max:width;

/\*.....\*/

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...../

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```

/*
 * Image.c - Image widget
 *
 */

#define XtStrlen(s)      ((s) ? strlen(s) : 0)

#include <stdio.h>
#include <ctype.h>
#include <X11/IntrinsicP.h>
#include <X11/StringDefs.h>
#include <X11/Xaw/XawInit.h>
#include "../include/ImageP.h"

#define streq(a,b) (strcmp( (a), (b) ) == 0)

/*****
 *
 * Full class record constant
 *
 *****/

/* Private Data */

static char defaultTranslations[] =
    "<Btn1Down>: notify()\n\
    <Btn1Motion>: notify()\n\
    <Btn1Up>: notify()";

#define offset(field) XtOffset(ImageWidget, field)

static XtResource resources[] = {
    {XtNbitmap, XtCPixmap, XtRBitmap, sizeof(Pixmap),

```



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```

        offset(image.pixmap), XtRImmediate, (caddr_t)None},
        {XtNcallback, XtCCallback, XtRCallback, sizeof(XtPointer),
        offset(image.callbacks), XtRCallback, (XtPointer)NULL},
};

```

```

static void Initialize();
static void Resize();
static void Redisplay();
static Boolean SetValues();
static void ClassInitialize();
static void Destroy();
static XtGeometryResult QueryGeometry();

```

```

static void Notify(), GetBitmapInfo();

```

```

static XtActionsRec      actionsList[] = {
    {"notify",    Notify},
};

```

```

ImageClassRec imageClassRec = {
    {
        /* core_class fields */
#define superclass      (&simpleClassRec)
        /* superclass      */      (WidgetClass) superclass,
        /* class_name      */      "Image",
        /* widget_size      */      sizeof(ImageRec),
        /* class_initialize */      ClassInitialize,
        /* class_part_initialize */  NULL,
        /* class_inited     */      FALSE,
        /* initialize       */      Initialize,
        /* initialize_hook   */      NULL,
        /* realize          */      XtInheritRealize,

```

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```

/* actions          */  actionsList,
/* num_actions      */  XtNumber(actionsList),
/* resources        */  resources,
/* num_resources    */  XtNumber(resources),
/* xrm_class        */  NULLQUARK,
/* compress_motion  */  TRUE,
/* compress_exposure */  TRUE,
/* compress_enterleave */  TRUE,
/* visible_interest */  FALSE,
/* destroy          */  Destroy,
/* resize           */  Resize,
/* expose           */  Redisplay,
/* set_values       */  SetValues,
/* set_values_hook   */  NULL,
/* set_values_almost */  XtInheritSetValuesAlmost,
/* get_values_hook   */  NULL,
/* accept_focus     */  NULL,
/* version          */  XtVersion,
/* callback_private  */  NULL,
/* tm_table         */  defaultTranslations,
/* query_geometry    */  QueryGeometry,
/* display_accelerator */  XtInheritDisplayAccelerator,
/* extension        */  NULL
},
/* Simple class fields initialization */
{
/* change_sensitive */  XtInheritChangeSensitive
}
};

WidgetClass imageWidgetClass = (WidgetClass)&imageClassRec;
/*****

```

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\* Private Procedures

\*

...../

static void ClassInitialize()

{

    extern void XmuCvtStringToBitmap();

    static XtConvertArgRec screenConvertArg[] = {

        {XtWidgetBaseOffset, (caddr\_t) XtOffset(Widget, core.screen),  
        sizeof(Screen \*)}

};

    XawInitializeWidgetSet();

    XtAddConverter("String", "Bitmap", XmuCvtStringToBitmap,  
        screenConvertArg, XtNumber(screenConvertArg));

} /\* ClassInitialize \*/

/\* ARGSUSED \*/

static void Initialize(request,new)

Widget request, new;

{

    ImageWidget iw = (ImageWidget) new;

    Dprintf("ImageInitialize\n");

    if (iw->image.pixmap == NULL)

        XtErrorMsg("NoBitmap", "asciiSourceCreate", "XawError",  
        "Image widget has no bitmap.", NULL, 0);

    GetBitmapInfo(new);

    if (iw->image.map\_width <= 0 || iw->image.map\_height <= 0)

        XtErrorMsg("NoDimension", "asciiSourceCreate", "XawError",  
        "Image widget illegal map dimension.", NULL, 0);

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```

    if (iw->core.width == 0) iw->core.width=iw->image.map_width;
    if (iw->core.height == 0) iw->core.height=iw->image.map_height;

    (*XtClass(new)->core_class.resize) ((Widget)iw);

} /* Initialize */

/*
 * Repaint the widget window
 */

/* ARGSUSED */
static void Redisplay(w, event, region)
    Widget w;
    XEvent *event;
    Region region;
{
    ImageWidget iw = (ImageWidget) w;

    Dprintf("ImageRedisplay\n");
    if (region != NULL &&
        XRectInRegion(region, 0, 0,
                      iw->image.map_width, iw->image.map_height)
        == RectangleOut)
        return;

    XCopyArea(
        XtDisplay(w), iw->image.pixmap, XtWindow(w),
        DefaultGC(XtDisplay(w), XDefaultScreen(XtDisplay(w))),
        0, 0, iw->image.map_width, iw->image.map_height, 0, 0);
}

```

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```
static void Resize(w)
    Widget w;
{
    ImageWidget iw = (ImageWidget)w;
    Dprintf("ImageResize\n");
}

/*
 * Set specified arguments into widget
 */

static Boolean SetValues(current, request, new, args, num_args)
    Widget current, request, new;
    ArgList args;
    Cardinal *num_args;
{
    ImageWidget curiw = (ImageWidget) current;
    ImageWidget reqiw = (ImageWidget) request;
    ImageWidget newiw = (ImageWidget) new;
    Boolean redisplay = False;

    /* recalculate the window size if something has changed. */

    if (curiw->image.pixmap != newiw->image.pixmap)
XFreePixmap(XtDisplay(curiw),curiw->image.pixmap);
    GetBitmapInfo(newiw);
    newiw->core.width = newiw->image.map_width;
    newiw->core.height = newiw->image.map_height;
    redisplay = True;

    return redisplay || XtIsSensitive(current) != XtIsSensitive(new);
}
```

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```
static void Destroy(w)
```

```
    Widget w;
```

```
{
```

```
    ImageWidget iw = (ImageWidget)w;
```

```
    Dprintf("ImageDestroy\n");
```

```
}
```

```
static XtGeometryResult QueryGeometry(w, intended, preferred)
```

```
    Widget w;
```

```
    XtWidgetGeometry *intended, *preferred;
```

```
{
```

```
    register ImageWidget iw = (ImageWidget)w;
```

```
    preferred->request_mode = CWWidth | CWHeight;
```

```
    preferred->width = iw->image.map_width;
```

```
    preferred->height = iw->image.map_height;
```

```
    if ( ((intended->request_mode & (CWWidth | CWHeight))
```

```
        == (CWWidth | CWHeight)) &&
```

```
        intended->width == preferred->width &&
```

```
        intended->height == preferred->height)
```

```
        return XtGeometryYes;
```

```
    else if (preferred->width == w->core.width &&
```

```
        preferred->height == w->core.height)
```

```
        return XtGeometryNo;
```

```
    else
```

```
        return XtGeometryAlmost;
```

```
}
```

```
static void GetBitmapInfo(w)
```

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```

Widget      w;

{
    ImageWidget iw=(ImageWidget)w;
    unsigned int  depth, bw;
    Window      root;
    int         x, y;
    unsigned int  width, height;
    char        buf[BUFSIZ];

    if (iw->image.pixmap != None) {
        if
(!XGetGeometry(XtDisplayOfObject(w),iw->image.pixmap,&root,&x,&y,&width,&height,&bw,&depth)) {
            sprintf(buf, "ImageWidget: %s %s \"%s\".", "Could not",
                "get Bitmap geometry information for Image ",
                XtName(w));
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        iw->image.map_width=(Dimension)width;
        iw->image.map_height=(Dimension)height;
    }
}

/*
 *   Action Procedures
 */

static void  Notify(w,event,params,num_params)

Widget      w;
XEvent      *event;

```

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String \*params;

Cardinal \*num\_params;

```
{
    ImageWidget iw=(ImageWidget)w;
    XButtonEvent *buttonevent=&event->xbution;
    int posn[2]={buttonevent->x,buttonevent->y};

    if (iw->image.map_width <= posn[0] || posn[0] < 0 ||
        iw->image.map_height <= posn[1] || posn[1] < 0) Dprintf("No
ImageNotify\n");
    else {
        Dprintf("ImageNotify\n");
        XtCallCallbackList(w,iw->image.callbacks,posn);
    }
}
```



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source/ImpKlicsTestSA.c

```
/*
    Test harness for KlicsFrameSA() in Klics.SA
*/

#include    "xwave.h"
#include    "KlicsSA.h"

void  ImpKlicsTestSA(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    int      sizeY=SA_WIDTH*SA_HEIGHT,
             sizeUV=SA_WIDTH*SA_HEIGHT/4;
    short  *dst[3]={
        (short *)MALLOC(sizeof(short)*sizeY),
        (short *)MALLOC(sizeof(short)*sizeUV),
        (short *)MALLOC(sizeof(short)*sizeUV),
    }, *src[3];
    Video  video=(Video)MALLOC(sizeof(VideoRec));
    int      i, z;
    char  file_name[STRLEN];
    Bits    bfp;
    Boolean  stillvid;

    strcpy(video->name,((XawListReturnStruct *)call_data)->string);
```

```

sprintf(file_name, "%s%s/%s%s\0", global->home, KLICS_SA_DIR, video->name, KLICS
_SA_EXT);

```

```

    bfp = bopen(file_name, "r");
    bread(&stillvid, 1, bfp);
    bread(&video->size[2], sizeof(int)*8, bfp);
    video->data[0] = (short **)MALLOC(sizeof(short *)*video->size[2]);
    video->data[1] = (short **)MALLOC(sizeof(short *)*video->size[2]);
    video->data[2] = (short **)MALLOC(sizeof(short *)*video->size[2]);
    video->disk = False;
    video->type = YUV;
    video->size[0] = SA_WIDTH;
    video->size[1] = SA_HEIGHT;
    video->UVsample[0] = 1;
    video->UVsample[1] = 1;
    video->trans.type = TRANS_None;
    for(z=0; z < video->size[2]; z++) {
        NewFrame(video, z);
        src[0] = video->data[0][z];
        src[1] = video->data[1][z];
        src[2] = video->data[2][z];
        KlicsFrameSA(z == 0 || stillvid?STILL:SEND, src, dst, bfp);
        SaveFrame(video, z);
        FreeFrame(video, z);
    }
    bclose(bfp);
    video->next = global->videos;
    global->videos = video;
    XtFree(dst[0]);
    XtFree(dst[1]);
    XtFree(dst[2]);
}

```

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## source/ImportKlics.c

```
/*
 *   Importing raw Klics binary files
 */

#include    "xwave.h"
#include    "Klics.h"

extern Bits    bopen();
extern void    bclose(), bread(), bwrite(), bflush();

extern void    SkipFrame();
extern int     HuffRead();
extern Boolean    BlockZero();
extern void    ZeroCoeffs();
extern int     ReadInt();
extern int     Decide();
extern double    DecideDouble();

Boolean    BoolToken(bfp)

Bits    bfp;

{
    Boolean    token;

    bread(&token, 1, bfp);
    return(token);
}
```

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```
void HuffBlock(block,bfp)
```

```
Block block;
```

```
Bits bfp;
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
        block[X][Y]=HuffRead(bfp);
```

```
}
```

```
void PrevBlock(old,addr,x,y,z,oct,sub,channel,ctrl)
```

```
Block old, addr;
```

```
int x, y, z, oct, sub, channel;
```

```
CompCtrl ctrl;
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
```

```
        addr[X][Y]=Access((x<<1)+X,(y<<1)+Y,oct,sub,Size(ctrl->dst,channel,0));
```

```
        old[X][Y]=ctrl->dst->data[channel][z][addr[X][Y]];
    }
```

```
}
```

```
void DeltaBlock(new,old,delta,step)
```

```
Block new, old, delta;
```

```
int step;
```

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```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

new[X][Y]=old[X][Y]+delta[X][Y]*step+(delta[X][Y]!=0?negif(delta[X][Y]<0,(step-1)
> > 1):0);
}

```

```
void    UpdateBlock(new,addr,z,channel,ctrl)
```

```
int    z, channel;
```

```
Block new, addr;
```

```
CompCtrl    ctrl;
```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        ctrl->dst->data[channel][z][addr[X][Y]]=(short)new[X][Y];
}

```

```
void    ReadKlicsHeader(ctrl)
```

```
CompCtrl    ctrl;
```

```

{
    KlicsHeaderRec    head;
    int    i;
    Video dst=ctrl->dst;

    fread(&head,sizeof(KlicsHeaderRec),1,ctrl->bfp->fp);
}

```

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```

ctrl->stillvid = head.stillvid;
ctrl->auto_q = head.auto_q;
ctrl->buf_switch = head.buf_switch;
ctrl->quant_const = head.quant_const;
ctrl->thresh_const = head.thresh_const;
ctrl->cmp_const = head.cmp_const;
ctrl->fps = head.fps;
for(i=0;i<5;i++) ctrl->base_factors[i] = head.base_factors[i];
ctrl->diag_factor = head.diag_factor;
ctrl->chrome_factor = head.chrome_factor;
ctrl->decide = head.decide;
strcpy(dst->name,ctrl->bin_name);
dst->type = head.type;
dst->disk = head.disk;
dst->gamma = head.gamma;
dst->rate = head.rate;
dst->start = head.start;
for(i=0;i<3;i++) dst->size[i] = head.size[i];
for(i=0;i<2;i++) dst->UVsample[i] = head.UVsample[i];
dst->trans = head.trans;
dst->precision = head.precision;
for(i=0;i<(dst->type == MONO?1:3);i++)
    dst->data[i] = (short **)MALLOC(dst->size[2]*sizeof(short *));
}

```

```

void WriteKlicsHeader(ctrl)

```

```

CompCtrl ctrl;

```

```

{
    KlicsHeaderRec head;
    int i;

```

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```

    head.stillvid = ctrl->stillvid;
    head.auto_q = ctrl->auto_q;
    head.buf_switch = ctrl->buf_switch;
    head.quant_const = ctrl->quant_const;
    head.thresh_const = ctrl->thresh_const;
    head.cmp_const = ctrl->cmp_const;
    head.fps = ctrl->fps;
    for(i=0; i<5; i++) head.base_factors[i] = ctrl->base_factors[i];
    head.diag_factor = ctrl->diag_factor;
    head.chrome_factor = ctrl->chrome_factor;
    head.decide = ctrl->decide;
    head.type = ctrl->dst->type;
    head.disk = ctrl->dst->disk;
    head.gamma = ctrl->dst->gamma;
    head.rate = ctrl->dst->rate;
    head.start = ctrl->dst->start;
    for(i=0; i<3; i++) head.size[i] = ctrl->dst->size[i];
    for(i=0; i<2; i++) head.UVsample[i] = ctrl->dst->UVsample[i];
    head.trans = ctrl->dst->trans;
    head.precision = ctrl->dst->precision;
    fwrite(&head, sizeof(KlicsHeaderRec), 1, ctrl->bfp->fp);
}

void KlicsTree(mode, x, y, z, oct, sub, channel, ctrl)

int mode, x, y, z, oct, sub, channel;
CompCtrl ctrl;

{
    Block addr, old, new, delta, zero_block = {{0,0},{0,0}};
    double norms[3] = {ctrl->quant_const, ctrl->thresh_const, ctrl->cmp_const};
    int step;

```

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```

PrevBlock(old,addr,x,y,z,oct,sub,channel,ctrl);
if (mode!=VOID) {
    CalcNormals(ctrl,oct,sub,channel,norms);
    step = norms[0] < 1.0?1:(int)norms[0];
    if (mode == STILL || BlockZero(old)) {
        if (BoolToken(ctrl->bfp)) { /* NON_ZERO_STILL */
            Dprintf("NON_ZERO_STILL\n");
            HuffBlock(delta,ctrl->bfp);
            DeltaBlock(new,old,delta,step);
            UpdateBlock(new,addr,z,channel,ctrl);
        } else {
            Dprintf("ZERO_STILL\n");
            mode=STOP; /* ZERO_STILL */
        }
    } else {
        if (!BoolToken(ctrl->bfp)) { /* BLOCK_SAME */
            Dprintf("BLOCK_SAME\n");
            mode=STOP;
        } else {
            if (!BoolToken(ctrl->bfp)) { /* ZERO_VID */
                Dprintf("ZERO_VID\n");
                ZeroCocffs(ctrl->dst->data[channel][z],addr);
                mode=VOID;
            } else { /*
BLOCK_CHANGE */
                Dprintf("BLOCK_CHANGE\n");
                HuffBlock(delta,ctrl->bfp);
                DeltaBlock(new,old,delta,step);
                UpdateBlock(new,addr,z,channel,ctrl);
            }
        }
    }
}
}

```



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```

    } else {
        if (BlockZero(old)) mode = STOP;
        else {
            ZeroCoeffs(ctrl->dst->data[channel][z],addr);
            mode = VOID;
        }
    }

    if (oct > 0 && mode != STOP) {
        Boolean    decend = mode == VOID?True:BoolToken(ctrl->bfp);
        int    X, Y;

        Dprintf("x = %d, y = %d, oct = %d sub = %d mode\n",x,y,oct,sub,mode);
        if (decend) {
            if (mode != VOID) Dprintf("OCT_NON_ZERO\n");
            for(Y=0;Y<2;Y++) for(X=0;X<2;X++)
                KlicsTree(mode,x*2+X,y*2+Y,z,oct-1,sub,channel,ctrl);
        } else if (mode != VOID) Dprintf("OCT_ZERO\n");
    }
}

void KlicsLPF(mode,z,ctrl)

CompCtrl    ctrl;
int    mode, z;

{
    Block    addr, old, new, delta;
    int    channel, channels=ctrl->dst->type == MONO?1:3, x, y,
        octs_lum=ctrl->dst->trans.wavelet.space[0],

    size[2] = {Size(ctrl->dst,0,0) >> octs_lum + 1, Size(ctrl->dst,0,1) >> octs_lum + 1};

```

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```

for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
    Boolean    lpf_loc= True;

    if (mode!= STILL) {
        lpf_loc= BoolToken(ctrl->bfp); /*
LPF_LOC_ZERO/LPF_LOC_NON_ZERO */

Dprintf("%s\n",lpf_loc?"LPF_LOC_NON_ZERO":"LPF_LOC_ZERO");
    }
    if (lpf_loc) for(channel=0;channel < channels;channel++) {
        int
octs=ctrl->dst->trans.wavelet.space[ctrl->dst->type==YUV && channel!=0?1:0],
        X, Y, step, value, bits=0;

        double
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};

        PrevBlock(old,addr,x,y,z,octs-1,0,channel,ctrl);
        CalcNormals(ctrl,octs-1,0,channel,norms);
        step= norms[0] < 1.0?1:(int)norms[0];
        if (mode== STILL) {
            for(bits=0,
value=((1 < < 8+ctrl->dst->precision)-1)/step;value!=0;bits++)
                value= value > > 1;
            for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
                delta[X][Y]= ReadInt(bits,ctrl->bfp);
            DeltaBlock(new,old,delta,step);
            UpdateBlock(new,addr,z,channel,ctrl);
        } else {
            if (BoolToken(ctrl->bfp)) { /*
LPF_ZERO/LPF_NON_ZERO */

                Dprintf("LPF_NON_ZERO\n");
                HuffBlock(delta,ctrl->bfp);

```

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```

        DeltaBlock(new,old,delta,step);
        UpdateBlock(new,addr,z.channel,ctrl);
    } else Dprintf("LPF_ZERO\n");
    }
}
}
}

void KlicsFrame(ctrl,z)

CompCtrl    ctrl;
int    z;

{
    Video dst=ctrl->dst;
    int    sub, channel, x, y, mode=ctrl->stillvid || z==0?STILL:SEND,
        octs_lum=dst->trans.wavelet.space[0],

size[2]={Size(dst,0,0)>>1+octs_lum,Size(dst,0,1)>>1+octs_lum};

    NewFrame(dst,z);
    CopyFrame(dst,z-1,z,ctrl->stillvid || z==0);
    if (z!=0 && ctrl->auto_q) {

ctrl->quant_const+=(double)(HISTO/2+ReadInt(HISTO_BITS,ctrl->bfp))*HISTO_DE
LTA*2.0/HISTO-HISTO_DELTA;

        ctrl->quant_const=ctrl->quant_const<0.0?0.0:ctrl->quant_const;
        Dprintf("New quant %f\n",ctrl->quant_const);
    }
    KlicsLPF(mode,z,ctrl);
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        if (BoolToken(ctrl->bfp)) {

```

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```

Dprintf("LOCAL_NON_ZERO\n");
for(channel = 0; channel < (dst-> type == MONO?1:3); channel++) {
    int    octs = dst-> trans.wavelet.space[dst-> type == YUV
&& channel != 0?1:0];

    if (BoolToken(ctrl-> bfp)) {
        Dprintf("CHANNEL_NON_ZERO\n");
        for(sub = 1; sub < 4; sub++)
            KlicsTree(mode, x, y, z, octs-1, sub, channel, ctrl);
    } else Dprintf("CHANNEL_ZERO\n");
}
} else Dprintf("LOCAL_ZERO\n");
}
}

```

```

void ImportKlics(w, closure, call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{

```

```

    char    file_name[STRLEN];

```

```

    CompCtrlRec ctrl;

```

```

    int     i, z;

```

```

    ctrl.dst = (Video)MALLOC(sizeof(VideoRec));

```

```

    strcpy(ctrl.bin_name, ((XawListReturnStruct *)call_data)-> string);

```

```

    sprintf(file_name, "%s%s/%s%s\0", global-> home, KLICS_DIR, ctrl.bin_name, KLICS_EX
T);

```

```

    ctrl.bfp = bopen(file_name, "r");

```

```

    ReadKlicsHeader(&ctrl);

```

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```
if (ctrl.dst->disk) SaveHeader(ctrl.dst);
for(z=0;z<ctrl.dst->size[2];z++) {
    if (z==0 || !ctrl.buf_switch) KlicsFrame(&ctrl,z);
    else {
        if (BoolToken(ctrl.bfp)) KlicsFrame(&ctrl,z);
        else SkipFrame(ctrl.dst,z);
    }
    if (z>0) {
        SaveFrame(ctrl.dst,z-1);
        FreeFrame(ctrl.dst,z-1);
    }
}
SaveFrame(ctrl.dst,ctrl.dst->size[2]-1);
FreeFrame(ctrl.dst,ctrl.dst->size[2]-1);
bclose(ctrl.bfp);
ctrl.dst->next=global->videos;
global->videos=ctrl.dst;
}
```

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source/ImportKlicsSA.c

...../

/\*

\* Importing raw Klics binary files

\*

\* Stand Alone version

\*/

#include "KlicsSA.h"

extern void Convolve();

/\* useful X definitions \*/

typedef char Boolean;

#define True 1

#define False 0

#define String char\*

extern int HuffReadSA();

extern Boolean BlockZeroSA();

extern void ZeroCoeffsSA();

extern int ReadIntSA();

extern int DecideSA();

extern double DecideDoubleSA();

Boolean BoolTokenSA(bfp)

Bits bfp;

{

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```

        Boolean    token;

        bread(&token,1,bfp);
        return(token);
    }

void  HuffBlockSA(block,bfp)

Block  block;
Bits   bfp;

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        block[X][Y]=HuffReadSA(bfp);
}

void  PrevBlockSA(old,addr,x,y,oct,sub,channel,dst)

Block  old, addr;
int     x, y, oct, sub, channel;
short  *dst[3];

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        addr[X][Y]=AccessSA((x<<1)+X,(y<<1)+Y,oct,sub,channel);
        old[X][Y]=dst[channel][addr[X][Y]];
    }
}

```

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```
void DeltaBlockSA(new,old,delta,step)
```

```
Block new, old, delta;
```

```
int step;
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
```

```
        new[X][Y] = old[X][Y] + delta[X][Y]*step + (delta[X][Y] != 0 ? negif(delta[X][Y] < 0, (step-1) > > 1):0);
```

```
}
```

```
void UpdateBlockSA(new,addr,channel,dst)
```

```
int channel;
```

```
Block new, addr;
```

```
short *dst[3];
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
```

```
        dst[channel][addr[X][Y]] = (short)new[X][Y];
```

```
}
```

```
void KlicsTreeSA(mode,x,y,oct,sub,channel,dst,bfp,quant_const)
```

```
int mode, x, y, oct, sub, channel;
```

```
short *dst[3];
```

```
Bits bfp;
```



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```
double    quant_const;
```

```
{
```

```
Block addr, old, new, delta, zero_block={{0,0},{0,0}};
```

```
double    norms[3]={quant_const,thresh_const,cmp_const};
```

```
int    step;
```

```
PrevBlockSA(old,addr,x,y,oct,sub,channel,dst);
```

```
if (mode!=VOID) {
```

```
    CalcNormalsSA(oct,sub,channel,norms,quant_const);
```

```
    step=norms[0]<1.0?1:(int)norms[0];
```

```
    if (mode==STILL || BlockZero(old)) {
```

```
        if (BoolTokenSA(bfp)) { /* NON_ZERO_STILL */
```

```
            Dprintf("NON_ZERO_STILL\n");
```

```
            HuffBlockSA(delta,bfp);
```

```
            DeltaBlockSA(new,old,delta,step);
```

```
            UpdateBlockSA(new,addr,channel,dst);
```

```
        } else {
```

```
            Dprintf("ZERO_STILL\n");
```

```
            mode=STOP; /* ZERO_STILL */
```

```
        }
```

```
    } else {
```

```
        if (!BoolTokenSA(bfp)) { /* BLOCK_SAME */
```

```
            Dprintf("BLOCK_SAME\n");
```

```
            mode=STOP;
```

```
        } else {
```

```
            if (!BoolTokenSA(bfp)) { /* ZERO_VID */
```

```
                Dprintf("ZERO_VID\n");
```

```
                ZeroCoeffsSA(dst[channel],addr);
```

```
                mode=VOID;
```

```
            } else {
```

```
                /*
```

```
            BLOCK_CHANGE */
```

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```

        Dprintf("BLOCK_CHANGE\n");
        HuffBlockSA(delta,bfp);
        DeltaBlockSA(new,old,delta,step);
        UpdateBlockSA(new,addr,channel,dst);
    }
}
}
} else {
    if (BlockZeroSA(old)) mode = STOP;
    else {
        ZeroCoeffsSA(dst[channel],addr);
        mode = VOID;
    }
}
if (oct > 0 && mode != STOP) {
    Boolean    decend = mode == VOID ? True : BoolTokenSA(bfp);
    int    X, Y;

    Dprintf("x = %d, y = %d, oct = %d sub = %d mode .
%d\n",x,y,oct,sub,mode);
    if (decend) {
        if (mode != VOID) Dprintf("OCT_NON_ZERO\n");
        for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

KlicsTreeSA(mode,x*2+X,y*2+Y,oct-1,sub,channel,dst,bfp,quant_const);
    } else if (mode != VOID) Dprintf("OCT_ZERO\n");
}
}

```

```

void KlicsLPF_SA(mode,dst,bfp,quant_const)

```

```

int    mode;

```

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```

short  *dst[3];
Bits   bfp;
double  quant_const;

{
    Block  addr, old, new, delta;
    int    channel, channels=3, x, y,
           octs_lum=3,

size[2] = {SA_WIDTH >> octs_lum+1, SA_HEIGHT >> octs_lum+1};

    for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
        Boolean  lpf_loc=True;

        if (mode!=STILL) {
            lpf_loc=BoolTokenSA(bfp); /*
LPF_LOC_ZERO/LPF_LOC_NON_ZERO */

Dprintf("%s\n",lpf_loc?"LPF_LOC_NON_ZERO":"LPF_LOC_ZERO");
        }
        if (lpf_loc) for(channel=0;channel < channels;channel++) {
            int    octs=channel!=0?2:3,
                   X, Y, step, value, bits=0;
            double  norms[3]={quant_const,thresh_const,cmp_const};

            PrevBlockSA(old,addr,x,y,octs-1,0,channel,dst);
            CalcNormalsSA(octs-1,0,channel,norms,quant_const);
            step=norms[0] < 1.0?1:(int)norms[0];
            if (mode==STILL) {
                for(bits=0,
value=((1 << 8+SA_PRECISION)-1)/step;value!=0;bits++)
                    value=value >> 1;

```

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```

        for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
            delta[X][Y]=ReadIntSA(bits,bfp);
        DeltaBlockSA(new,old,delta,step);
        UpdateBlockSA(new,addr,channel,dst);
    } else {
        if (BoolTokenSA(bfp)) { /* LPF_ZERO/LPF_NON_ZERO
*/
            Dprintf("LPF_NON_ZERO\n");
            HuffBlockSA(delta,bfp);
            DeltaBlockSA(new,old,delta,step);
            UpdateBlockSA(new,addr,channel,dst);
        } else Dprintf("LPF_ZERO\n");
    }
}
}
}
}

```

```

void KlicsFrameSA(mode,src,dst,bfp)

```

```

int mode;

```

```

short *src[3], *dst[3];

```

```

Bits bfp;

```

```

{

```

```

    int sub, channel, x, y, i,

```

```

        octs_lum=3,

```

```

size[2]={SA_WIDTH>>1+octs_lum,SA_HEIGHT>>1+octs_lum};

```

```

    double quant_const;

```

```

    bread((char *)&quant_const,sizeof(double)*8,bfp);

```

```

    KlicsLPF_SA(mode,dst,bfp,quant_const);

```

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```

for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
    if (BoolTokenSA(bfp)) {
        Dprintf("LOCAL_NON_ZERO\n");
        for(channel=0;channel < 3;channel++) {
            int    octs=channel!=0?2:3;

            if (BoolTokenSA(bfp)) {
                Dprintf("CHANNEL_NON_ZERO\n");
                for(sub=1;sub < 4;sub++)

                    KlicsTreeSA(mode,x,y,octs-1,sub,channel,dst,bfp,quant_const);
            } else Dprintf("CHANNEL_ZERO\n");
        }
    } else Dprintf("LOCAL_ZERO\n");
}
for(channel=0;channel < 3;channel++) {
    int
    frame_size[2]={SA_WIDTH >> (channel==0?0:1),SA_HEIGHT >> (channel==0?0:1
    )},

    frame_area=frame_size[0]*frame_size[1];

    for(i=0;i < frame_area;i++) src[channel][i]=dst[channel][i];
    Convolve(src[channel],False,frame_size,channel==0?3:2,0);
    for(i=0;i < frame_area;i++)
        src[channel][i]=src[channel][i] >> SA_PRECISION;
}
}

```

source/InitFrame.c

```
/*
    Initialise frame structure for Frame command widget
*/

#include    "../include/xwave.h"

#define     FRAME_ICONS      14
#define     TRANS_MENU      1
#define     COMP_MENU        2

extern void CopyVideo();
extern void Compare();
extern void NAO();
extern void FrameDestroy();
extern void Examine();
extern void FramePointYN();
extern void FrameInfo();
extern void FrameMerge();
extern void Movie();
extern void PostScript();
extern void Select();
extern void Spectrum();
extern void NewPoint();
extern void Transform();
extern void Compress();
extern String *VideoCurrentList();
extern void KlicsSA();

void InitFrame    (w,closure,call_data)
```

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```

Widget      w;
caddr_t     closure, call_data;

{
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    Video video=FindVideo(name->string,global->videos);
    Frame frame=(Frame)MALLOC(sizeof(FrameRec));
    Widget     shell[2], form, widgets[FRAME_ICONS],
trans_widgets[TRANS_MENU], comp_widgets[COMP_MENU];
    Arg  args[7];
    Pixmap  pixmap;
    int  view[2]={15+video->size[0],15+video->size[1]};
    FormItem  items[]={
        {"frm_cancel",      "frame_close",          0,0,FW_icon,NULL},
        {"frm_copy", "copy",          1,0,FW_icon,NULL},
        {"frm_exam",      "examine",          2,0,FW_icon,NULL},
        {"frm_point_yn","point_y",          3,0,FW_icon,NULL},
        {"frm_transform","transform",
4,0,FW_icon_button,"frm_trans_menu"},
        {"frm_info_yn",      "info",
5,0,FW_icon,NULL},
        {"frm_merge",      "merge",          6,0,FW_toggle,NULL},
        {"frm_compress","code",
7,0,FW_icon_button,"frm_comp_menu"},
        {"frm_movie",      "movie",          8,0,FW_icon,NULL},
        {"frm_postscript","postscript",      9,0,FW_icon,NULL},
        {"frm_compare",      "compare",      10,0,FW_icon,NULL},
        {"frm_view", NULL,
0,1,FW_view,(String)view},
        {"frm_label", video->name,          0,12,FW_label,NULL},
        {"frm_colors",      "colors",          13,12,FW_icon,NULL},
    };
};

```

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```

Selection    sel = (Selection)MALLOC(sizeof(SelectItem));
MenuItem     trans_menu[TRANS_MENU] = {
    {"trans_Wavelet", smeBSBObjectClass, "Wavelet", NULL},
};
MenuItem     comp_menu[COMP_MENU] = {
    {"comp_KLICS", smeBSBObjectClass, "KLICS", NULL},
    {"comp_KLICS_SA", smeBSBObjectClass, "KLICS SA", NULL},
};
XtCallbackRec frame_call[] = {
    {FrameDestroy, (caddr_t)frame}, {Free, (caddr_t)sel}, {NULL, NULL},
    {CopyVideo, (caddr_t)video}, {NULL, NULL},
    {Examine, (caddr_t)frame}, {NULL, NULL},
    {FramePointYN, (caddr_t)frame}, {NULL, NULL},
    {FrameInfo, (caddr_t)frame}, {NULL, NULL},
    {FrameMerge, (caddr_t)frame}, {NULL, NULL},
    {Movie, (caddr_t)frame}, {NULL, NULL},
    {PostScript, (caddr_t)frame}, {NULL, NULL},
    {Select, (caddr_t)sel}, {NULL, NULL},
    {Spectrum, (caddr_t)frame}, {NULL, NULL},
}, image_call[] = {
    {NewPoint, (caddr_t)frame}, {NULL, NULL},
}, trans_call[] = {
    {Transform, (caddr_t)video}, {NULL, NULL},
}, comp_call[] = {
    {Compress, (caddr_t)video}, {NULL, NULL},
    {KlicsSA, (caddr_t)video}, {NULL, NULL},
};

Colormap     cmap = ChannelCmap(frame->channel = (video->type == MONO
|| video->trans.type != TRANS_None)?0:3, video->type, video->gamma);

Dprintf("InitFrame\n");

```



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```
sel->name="video_Compare";
sel->button="frm_compare";
sel->list_proc=VideoCurrentList;
sel->action_name="Compare videos";
sel->action_proc=Compare;
sel->action_closure=(caddr_t)video;
frame->video=video;
frame->shell=ShellWidget("frm_shell",global->oplevel,SW_top,cmap,NULL);
form=FormatWidget("frm_form",frame->shell);
frame->image_widget=NULL;

frame->msg=NULL;

frame->zoom=0;
frame->frame=0;

frame->point_switch=False;
frame->point_merge=False;

frame->point=(Point)MALLOC(sizeof(PointRec));
frame->point->location[0]=0;
frame->point->location[1]=0;
frame->point->usage=1;
frame->point->next=global->points;
global->points=frame->point;

frame->palette=0;

frame->next=global->frames;
global->frames=frame;

GetFrame(video,frame->frame);
```

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```
pixmap = UpdateImage(frame);
```

```
FillForm(form,FRAME_ICONS.items,widgets,frame_call);
```

```
shell[0] = ShellWidget("frm_trans_menu",widgets[4],SW_menu,NULL,NULL);
```

```
FillMenu(shell[0],TRANS_MENU,trans_menu,trans_widgets,trans_call);
```

```
shell[1] = ShellWidget("frm_comp_menu",widgets[7],SW_menu,NULL,NULL);
```

```
FillMenu(shell[1],COMP_MENU,comp_menu,comp_widgets,comp_call);
```

```
frame->point_merge_widget = widgets[6];
```

```
XtSetArg(args[0],XtNbitmap,pixmap);
```

```
XtSetArg(args[1],XtNwidth,video->size[0]);
```

```
XtSetArg(args[2],XtNheight,video->size[1]);
```

```
XtSetArg(args[3],XtNcallback,image_call);
```

```
frame->image_widget = XtCreateManagedWidget("frm_image",imageWidgetClass,widget
s[11],args,FOUR);
```

```
XtSetSensitive(frame->image_widget,False);
```

```
XtSetSensitive(widgets[13],PseudoColor == global->visinfo->class);
```

```
XtPopup(frame->shell,XtGrabNone);
```

```
}
```

```
Video FindVideo(name,video)
```

```
String name;
```

```
Video video;
```

```
{
```

```
if (video == NULL) return(NULL);
```

```
else if (!strcmp(name,video->name)) return(video);
```

```
else return(FindVideo(name,video->next));
```

```
}
```

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source/InitMain.c

/\*

Initialise menu structure for Main command widget

\*/

#include "../include/xwave.h"

/\* Save externs \*/

extern void VideoSave();

extern void VideoXimSave();

extern void VideoDTSave();

extern void VideoMacSave();

extern void VideoHexSave();

/\* List externs \*/

extern String \*VideoList();

extern String \*VideoDropList();

extern String \*VideoCurrentList();

extern String \*KlicsList();

extern String \*KlicsListSA();

/\* Import externs \*/

extern void ImportKlics();

extern void ImpKlicsTestSA();

/\* Main externs \*/

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```

extern void  Select();
extern void  VideoClean();
extern void  Quit();
extern void  VideoLoad();
extern void  InitFrame();
extern void  VideoDrop();
extern void  PlotGraph();

```

```

/*    Function Name:    InitMain
 *    Description:    Create main menu button & sub-menus
 *    Arguments:    none
 *    Returns:    none
 */

```

```

#define    MAIN_MENU    7
#define    SAVE_MENU    5
#define    IMPT_MENU    2

```

```

InitMain()

```

```

{
    Widget      form=FormatWidget("xwave_form",global->toplevel), widgets[1],
                main_shell, main_widgets[MAIN_MENU],
                save_shell, save_widgets[SAVE_MENU],
                impt_shell, impt_widgets[IMPT_MENU];
    FormItem    items[]={
                {"xwaveLogo","main",0,0,FW_icon_button,"xwave_main_sh"},
    };
    MenuItem    main_menu[]={
                {"main_Open",smeBSBObjectClass,"Open a video",NULL},
                {"main_Attach",smeBSBObjectClass,"Attach a frame",NULL},
                {"main_Save",smeBSBprObjectClass,"Save a video","xwave_save_sh"},
    };
}

```

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```

        {"main_Drop", smeBSBObjectClass, "Drop a video", NULL},
        {"main_Clean", smeBSBObjectClass, "Clean out videos", NULL},
        {"main_Import", smeBSBprObjectClass, "Import a
video", "xwave_impt_sh"},
        {"main_Quit", smeBSBObjectClass, "Quit", NULL},
    }, save_menu[] = {
        {"save_menu_vid", smeBSBObjectClass, "Save xwave video", NULL},
        {"save_menu_xim", smeBSBObjectClass, "Save xim video", NULL},
        {"save_menu_dt", smeBSBObjectClass, "Save DT image", NULL},
        {"save_menu_mac", smeBSBObjectClass, "Save mac video", NULL},
        {"save_menu_hex", smeBSBObjectClass, "Save hex dump", NULL},
    }, impt_menu[] = {
        {"impt_menu_klics", smeBSBObjectClass, "KLICS", NULL},
        {"impt_menu_klicsSA", smeBSBObjectClass, "KLICS SA", NULL},
    };
    static SelectItem selection[] = {
        {"video_Open", "xwaveLogo", VideoList, "Open a
video", VideoLoad, NULL},
        {"frame_Attach", "xwaveLogo", VideoCurrentList, "Attach a
frame", InitFrame, NULL},
        {"video_Drop", "xwaveLogo", VideoDropList, "Drop a
video", VideoDrop, NULL},
    }, save_sel[] = {
        {"save_vid", "xwaveLogo", VideoCurrentList, "Save xwave
video", VideoSave, NULL},
        {"save_xim", "xwaveLogo", VideoCurrentList, "Save xim
video", VideoXimSave, NULL},
        {"save_dt", "xwaveLogo", VideoCurrentList, "Save DT
image", VideoDTSave, NULL},
        {"save_mac", "xwaveLogo", VideoCurrentList, "Save mac
video", VideoMacSave, NULL},
        {"save_hex", "xwaveLogo", VideoCurrentList, "Save hex

```

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```

dump",VideoHexSave,NULL},
    }, impt_sel[]={
        {"impt_klics","xwaveLogo",KlicsList,"Import
KLICS".ImportKlics,NULL},
        {"impt_klicsSA","xwaveLogo",KlicsListSA,"Import KLICS
SA".ImpKlicsTestSA,NULL},
    };
XtCallbackRec      main_call[]={
    {Select,(caddr_t)&selection[0]}, {NULL,NULL},
    {Select,(caddr_t)&selection[1]}, {NULL,NULL},
    {Select,(caddr_t)&selection[2]}, {NULL,NULL},
    {VideoClean,(caddr_t)NULL}, {NULL,NULL},
    {Quit,(caddr_t)NULL}, {NULL,NULL},
}, save_call[]={
    {Select,(caddr_t)&save_sel[0]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[1]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[2]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[3]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[4]}, {NULL,NULL},
}, impt_call[]={
    {Select,(caddr_t)&impt_sel[0]}, {NULL,NULL},
    {Select,(caddr_t)&impt_sel[1]}, {NULL,NULL},
};
Dprintf("InitMain\n");
FillForm(form,ONE,items,widgets,NULL);
main_shell=ShellWidget("xwave_main_sh",widgets[0],SW_menu,NULL,NULL);
save_shell=ShellWidget("xwave_save_sh",main_shell,SW_menu,NULL,NULL);
impt_shell=ShellWidget("xwave_impt_sh",main_shell,SW_menu,NULL,NULL);
FillMenu(main_shell,MAIN_MENU,main_menu,main_widgets,main_call);
FillMenu(save_shell,SAVE_MENU,save_menu,save_widgets,save_call);
FillMenu(impt_shell,IMPT_MENU,impt_menu,impt_widgets,impt_call);

```

}

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source/Klics5.c

```
/*
    Full still/video Knowles-Lewis Image Compression System utilising HVS
    properties
    and delta-tree coding
*/

#include "xwave.h"
#include "Klics.h"
#include <math.h>

extern Bits bopen();
extern void bclose(), bread(), bwrite(), bflush();

extern WriteKlicsHeader();

/* token modes (empty) */
#define EMPTY 0
#define CHANNEL_EMPTY 1
#define OCTAVE_EMPTY 2
#define LPF_EMPTY 3
#define FULL 4

typedef struct _HistRec {
    int bits, octbits[3][5], lpf, activity, target, token[TOKENS], coeff[129];
    double q_const;
} HistRec, *Hist; /* history record */

/* Function Name: Access
 * Description: Find index address from co-ordinates
```

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```

*   Arguments:  x, y - (x,y) co-ordinates
*               oct, sub, channel - octave, sub-band and channel co-ordinates
*               width - image data width
*   Returns: index into vid->data[channel][index]
*/

```

```
int   Access(x,y,oct,sub,width)
```

```
int   x, y, oct, sub, width;
```

```

{
    return(((x < < 1)+(sub > > 1)+width*((y < < 1)+(1&sub))) < < oct);
}

```

```

/*   Function Name:    LastFrame
*   Description:    Find last frame encoded
*   Arguments:    z - index of current frame
*               hist - history records
*   Returns:    index of previous frame
*/

```

```
int   LastFrame(z,hist)
```

```
int   z;
```

```
Hist hist;
```

```

{
    int   i=z-1;

    while(hist[i].bits==0 && i>0) i--;
    return(i<0?0:i);
}

```



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```

/*   Function Name:   Decide
   *   Description:   Calculate value representing the difference between new and old
   blocks
   *   Arguments:    new, old - blocks to compare
   *
                       mode - differencing algorithm {MAXIMUM | SIGABS |
SIGSQR}
   *   Returns:      difference value
   */

```

```

int   Decide(new,old,mode)

```

```

Block new, old;

```

```

int   mode;

```

```

{
    int   X, Y, sigma=0;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        int   n_o=new[X][Y]-old[X][Y];

        switch(mode) {
            case MAXIMUM:
                sigma=sigma>abs(n_o)?sigma:abs(n_o);
                break;
            case SIGABS:
                sigma+=abs(n_o);
                break;
            case SIGSQR:
                sigma+=n_o*n_o;
                break;
        }
    }
}

```

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```
        return(sigma);
    }

/*    Function Name:    DecideDouble
 *    Description:    Calculates normal w.r.t differencing algorithm
 *    Arguments:    norm - normal value
 *                  mode - differencing algorithm {MAXIMUM | SIGABS |
SIGSQR}
 *    Returns:    new normal value
 */

double    DecideDouble(norm,mode)

double    norm;
int    mode;

{
    double    ret;

    switch(mode) {
    case MAXIMUM:
        ret = norm;
        break;
    case SIGABS:
        ret = 4.0*norm;
        break;
    case SIGSQR:
        ret = 4.0*norm*norm;
        break;
    }
    return(ret);
}
```

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Boolean      Decision(new,old,norm,mode)

Block new, old;

double      norm;

int      mode;

```
{
    return((double)Decide(new,old,mode) <= DecideDouble(norm,mode));
}
```

/\*      Function Name:      Feedback

\*      Description:      Calculates new target activity from target bits and historical values

\*      Arguments:      hist - history records

\*                      curr - current frame

\*                      taps - size of history window

\*      Returns:      target activity

\*/

int      Feedback(hist,curr,taps)

int      curr;

Hist      hist;

int      taps;

```
{
    int      prev=curr, i;
    double      ratio=0;

    for(i=0;i < taps && prev!=0;i++) {
        prev=LastFrame(prev,hist);
```

```
ratio += (double)hist[prev].activity/(double)(hist[prev].bits-(prev == 0?hist[0].lpf:0));
```

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```

    }
    return((int)(ratio*(double)hist[curr].target/(double)i));
}

/*  Function Name:      Filter
 *  Description:  Calculates new q_const filtering historical values
 *  Arguments:   hist - history records
 *
 *               curr - current frame
 *               taps - size of history window
 *               filter - index to filter
 *  Returns:      q_const
 */

double      Filter(hist,curr,taps,filter)

int  curr;
Hist hist;
int  taps, filter;

{
    double      mac=hist[curr].q_const, sum=1.0, coeff=1.0;
    int  i, prev=curr;

    for(i=0;i<taps && prev!=0;i++) {
        prev=LastFrame(prev,hist);
        coeff=filter==0?0:coeff/2.0;
        mac+=hist[prev].q_const*coeff;
        sum+=coeff;
    }
    return(mac/sum);
}

```

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```

/*  Function Name:   Huffman
 *   Description:   Calculates the number of bits for the Huffman code representing
level
 *   Arguments:    level - level to be encoded
 *   Returns:      number of bits in codeword
 */

```

```
int  Huffman(level)
```

```
int  level;
```

```

{
    return(level == 0?2:(abs(level) < 3?3:1 + abs(level)));
}

```

```

/*  Function Name:   HuffCode
 *   Description:   Generates Huffman code representing level
 *   Arguments:    level - level to be encoded
 *   Returns:      coded bits in char's
 */

```

```
unsigned char *HuffCode(level)
```

```
int  level;
```

```

{
    unsigned char *bytes=(unsigned char *)MALLOC((7+Huffman(level))/8);

    bytes[0]=(abs(level) < 3?abs(level):3) | (level < 0?4:0);
    if (abs(level) > 2) {
        int  index=(7+Huffman(level))/8-1;

```

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```
        bytes[index] = bytes[index] | (1 << (Huffman(level)-1)%8);
    }
    return(bytes);
}
```

```
unsigned char *CodeInt(number,bits)
```

```
int    number, bits;
```

```
{
    int    len=(7+bits)/8;
    unsigned char *bytes=(unsigned char *)MALLOC(len);
    int    byte;

    for(byte=0;byte<len;byte++) {
        bytes[byte]=0xff&number;
        number=number>>8;
    }
    return(bytes);
}
```

```
int    ReadInt(bits,bfp)
```

```
int    bits;
```

```
Bits   bfp;
```

```
{
    int    len=(7+bits)/8;
    unsigned char bytes[len];
    int    byte, number=0;

    bread(bytes,bits,bfp);
```

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```

    for(byte=0;byte < len;byte++)
        number = number | ((int)bytes[byte] << byte*8);
    number = (number << sizeof(int)*8-bits) >> sizeof(int)*8-bits;
    return(number);
}

/*  Function Name:      HuffRead
 *   Description:      Read Huffman encoded number from binary file
 *   Arguments:        bfp - binary file pointer
 *   Returns:          decoded level
 */

int  HuffRead(bfp)

Bits  bfp;

{
    int    value;
    unsigned char    byte;
    Boolean    negative=False;

    bread(&byte,2,bfp);
    value=(int)byte;
    if (byte=='\0') return(0);
    else {
        bread(&byte,1,bfp);
        negative=(byte!='\0');
    }
    if (value < 3) return(negif(negative,value));
    for(byte='\0';byte=='\0';value++) bread(&byte,1,bfp);
    return(negif(negative,value-1));
}

```

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```

/*  Function Name:    Quantize
 *  Description:    RM8 style quantizer
 *  Arguments:    data - unquantised number
 *                q - quantizing divisor
 *                level - quantised to level
 *  Returns:      quantized data & level
 */

```

```
int  Quantize(data,q,level)
```

```
int  data, q, *level;
```

```

{
    int  mag_level=abs(data)/q;

    *level=negif(data<0,mag_level);
    return(negif(data<0,mag_level*q+(mag_level!=0?(q-1)>>1:0)));
}

```

```

/*  Function Name:    Proposed
 *  Description:    Calculates proposed block values
 *  Arguments:    pro - proposed block
 *                lev - proposed block quantized levels
 *                old, new - old and new block values
 *                decide - decision algorithm
 *                norms - HVS normals
 *  Returns:      new==0, proposed values (pro) and levels (lev)
 */

```

```
Boolean  Proposed(pro,lev,old,new,decide,norms)
```

```
Block  pro, lev, old, new;
```



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```

int    decide;
double    norms[3];

{
    Block  zero_block={{0,0},{0,0}};
    int    X, Y, step=norms[0]<1.0?1:(int)norms[0];
    Boolean    zero=Decision(new,zero_block,norms[1],decide);

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=zero?0:old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));
    return(zero);
}

```

```

/*    Function Name:    ZeroCoeffs
*    Description:    Zero out video data
*    Arguments:    data - image data
*                  addr - addresses
*    Returns:    zeros data[addr[]]
*/

```

```
void  ZeroCoeffs(data,addr)
```

```
short *data;
```

```
Block addr;
```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        data[addr[X][Y]]=0;.
}

```

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```

/*  Function Name:    BlockZero
 *   Description:    Test if all block values are zero
 *   Arguments:      block - block under test
 *   Returns:        block == 0
 */

```

```

Boolean    BlockZero(block)

```

```

Block block;

```

```

{
    int    X, Y;
    Boolean    zero = True;

    for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
        if (block[X][Y] != 0) zero = False;
    return(zero);
}

```

```

/*  Function Name:    SendToken
 *   Description:    Increments token frequency
 *   Arguments:      token - token to be transmitted
 *                   channel, sub, oct - co-ordinates
 *                   ctrl - control record for compression
 *                   hist - history record
 *                   empty - zero state {EMPTY | CHANNEL_EMPTY |
OCTAVE_EMPTY | LPF_EMPTY | FULL}
 *                   branch - branch of tree (0-3)
 *   Returns:        encodes token
 */

```

```

void    SendToken(token,channel,sub,oct,ctrl,hist,empty,branch)

```

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```

int    token, channel, sub, oct, *empty, branch;
CompCtrl  ctrl;
Hist  hist;

{
    int    full=FULL, i;
    String
token_name[TOKENS]={ "ZERO_STILL", "NON_ZERO_STILL", "BLOCK_SAME", "ZE
RO_VID", "BLOCK_CHANGE",

"LOCAL_ZERO", "LOCAL_NON_ZERO", "CHANNEL_ZERO", "CHANNEL_NON_ZE
RO", "OCT_ZERO", "OCT_NON_ZERO",

"LPF_ZERO", "LPF_NON_ZERO", "LPF_LOC_ZERO", "LPF_LOC_NON_ZERO"};

    switch(*empty) {
    case EMPTY:
        if (token!= ZERO_STILL && token!= BLOCK_SAME) {

SendToken(LOCAL_NON_ZERO, channel, sub, oct, ctrl, hist, &full, branch);
            for(i=0; i < channel; i++)
SendToken(CHANNEL_ZERO, i, sub, oct, ctrl, hist, &full, branch);
                *empty=CHANNEL_EMPTY;
                SendToken(token, channel, sub, oct, ctrl, hist, empty, branch);
            }
            break;
        case CHANNEL_EMPTY:
            if (token!= ZERO_STILL && token!= BLOCK_SAME) {

SendToken(CHANNEL_NON_ZERO, channel, sub, oct, ctrl, hist, &full, branch);
                for(i=1; i < sub; i++)
SendToken(token==NON_ZERO_STILL?ZERO_STILL:BLOCK_SAME, channel, i, oct, ct

```

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```

    rl.hist.&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case OCTAVE_EMPTY:
    if (token!= ZERO_STILL && token!= BLOCK_SAME) {

SendToken(OCT_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i < branch;i++)
SendToken(token==NON_ZERO_STILL?ZERO_STILL:BLOCK_SAME,channel,sub,oc
t,ctrl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case LPF_EMPTY:
    if (token!= LPF_ZERO) {

SendToken(LPF_LOC_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i < channel;i++)
SendToken(LPF_ZERO,i,sub,oct,ctrl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case FULL:
    Dprintf("%s\n",token_name[token]);
    hist->token[token]++;
    hist->bits+=token_bits[token];
    hist->octbits[channel][oct]+=token_bits[token];
    if (ctrl->bin_switch)

```

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```
bwrite(&token_codes[token],token_bits[token],ctrl->bfp);
```

```
    break;
```

```
    }
```

```
}
```

```
/*  Function Name:      ReadBlock
```

```
    *  Description:    Read block from video
```

```
    *  Arguments:     new, old, addr - new and old blocks and addresses
```

```
    *                  x, y, z, oct, sub, channel - co-ordinates of block
```

```
    *                  ctrl - compression control record
```

```
    *  Returns:       block values
```

```
*/
```

```
void  ReadBlock(new,old,addr,x,y,z,oct,sub,channel,ctrl)
```

```
Block new, old, addr;
```

```
int   x, y, z, oct, sub, channel;
```

```
CompCtrl  ctrl;
```

```
{
```

```
    int   X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
```

```
        addr[X][Y]=Access((x<<1)+X,(y<<1)+Y,oct,sub,Size(ctrl->src,channel,0));
```

```
        new[X][Y]=(int)ctrl->src->data[channel][z][addr[X][Y]];

```

```
        old[X][Y]=(int)ctrl->dst->data[channel][z][addr[X][Y]];

```

```
    }
```

```
}
```

```
/*  Function Name:      CalcNormals
```

```
    *  Description:    Calculates HVS weighted normals
```

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- \* Arguments: ctrl - compression control record
- \* oct, sub, channel - co-ordinates
- \* norms - pre-initialised normals
- \* Returns: weighted normals
- \*/

```
void CalcNormals(ctrl,oct,sub,channel,norms)
```

```
CompCtrl ctrl;
```

```
int oct, sub, channel;
```

```
double norms[3];
```

```
{
```

```
Video vid=ctrl->dst;
```

```
int norm, base_oct=oct+(vid->type==YUV &&
```

```
channel!=0?vid->trans.wavelet.space[0]-vid->trans.wavelet.space[1]:0)+(sub==0?1:0)
```

```
;
```

```
for(norm=0;norm<3;norm++) {
```

```
if (norm!=0) norms[norm] *= ctrl->quant_const;
```

```
norms[norm] *=
```

```
ctrl->base_factors[base_oct]*(sub==3?ctrl->diag_factor:1.0);
```

```
if (channel!=0) norms[norm] *= ctrl->chrome_factor;
```

```
norms[norm] *=(double)(1<<vid->precision);
```

```
}
```

```
}
```

```
/* Function Name: MakeDecisions
```

```
* Description: Decide on new compression mode from block values
```

```
* Arguments: old, new, pro - block values
```

```
* zero - zero flag for new block
```

```
* norms - HVS normals
```

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- \* mode - current compression mode
- \* decide - comparison algorithm
- \* Returns: new compression mode
- \*/

```
int MakeDecisions(old,new,pro,zero,norms,mode,decide)
```

```
Block new, old, pro;
```

```
Boolean zero;
```

```
double norms[3];
```

```
int mode, decide;
```

```
{
```

```
Block zero_block={{0,0},{0,0}};
```

```
int new_mode, np=Decide(new,pro,decide), no=Decide(new,old,decide);
```

```
if (np < no && (double)no > DecideDouble(norms[mode == STILL?1:2],decide)
&& !zero)
```

```
new_mode=mode == STILL ||
```

```
(double)Decide(old,zero_block,decide) <= DecideDouble(norms[1],decide)?STILL:SEND;
```

```
else new_mode=mode == SEND && np < no && zero?VOID:STOP;
```

```
return(new_mode);
```

```
}
```

```
int MakeDecisions2(old,new,pro,lev,zero,norms,mode,decide)
```

```
Block new, old, pro, lev;
```

```
Boolean zero;
```

```
double norms[3];
```

```
int mode, decide;
```

```
{
```

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```

Block zero_block = {{0,0},{0,0}};
int    new_mode = mode == STILL || BlockZero(old)?STILL:SEND,
        np = Decide(new,pro,decide), no = Decide(new.old,decide);

    if (new_mode == STILL) new_mode = np > no || zero ||
BlockZero(lev)?STOP:STILL;
    else new_mode = zero && np < no?VOID:np > no ||
Decision(new,old,norms[2],decide) || BlockZero(lev)?STOP:SEND;
    return(new_mode);
}

```

```

/*  Function Name:    UpdateCoeffs
*   Description:    Encode proposed values and write data
*   Arguments:    pro, lev, addr - proposed block, levels and addresses
*                   z, channel, oct - co-ordinates
*                   ctrl - compression control record
*                   hist - history record
*   Returns:    alters ctrl->dst->data[channel][z][addr[]]
*/

```

```

void UpdateCoeffs(pro,lev,addr,z,channel,oct,ctrl,hist)

```

```

Block pro, lev, addr;
int    z, channel, oct;
CompCtrl ctrl;
Hist hist;

```

```

{
    int    X, Y;

    for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++) {
        int    bits = Huffman(lev[X][Y]),

```



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```
level = abs(lev[X][Y]);
```

```
ctrl->dst->data[channel][z][addr[X][Y]] = (short)pro[X][Y];
```

```
hist->coeff[level > 128?128:level] ++;
```

```
hist->bits += bits;
```

```
hist->octbits[channel][oct] += bits;
```

```
if (ctrl->bin_switch) {
```

```
    unsigned char    *bytes = HuffCode(lev[X][Y]);
```

```
    bwrite(bytes, bits, ctrl->bfp);
```

```
    XtFree(bytes);
```

```
}
```

```
}
```

```
}
```

```
/*  Function Name:    SendTree
 *
 *  Description:    Encode tree blocks
 *
 *  Arguments:    prev_mode - compression mode
 *
 *                x, y, z, oct, sub, channel - co-ordinates
 *
 *                ctrl - compression control record
 *
 *                hist - history records
 *
 *                empty - token mode
 *
 *                branch - tree branch number
 *
 *  Returns:    active block indicator
 */
```

```
Boolean    SendTree(prev_mode, x, y, z, oct, sub, channel, ctrl, hist, empty, branch)
```

```
int    prev_mode, x, y, z, oct, sub, channel, *empty, branch;
```

```
CompCtrl    ctrl;
```

```
Hist    hist;
```

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```

{
    Block addr, old, new, pro, lev;
    int    new_mode, X, Y;
    double

norms[3] = {ctrl->quant_const, ctrl->thresh_const, ctrl->cmp_const}; /* quant, thresh,
compare */
    Boolean    active = False;

    ReadBlock(new, old, addr, x, y, z, oct, sub, channel, ctrl);
    if (prev_mode != VOID) {
        Boolean    zero;

        CalcNormals(ctrl, oct, sub, channel, norms);
        zero = Proposed(pro, lev, old, new, ctrl->decide, norms);
    /*
new_mode = MakeDecisions(old, new, pro, zero, norms, prev_mode, ctrl->decide); */

new_mode = MakeDecisions2(old, new, pro, lev, zero, norms, prev_mode, ctrl->decide);
        switch(new_mode) {
            case STOP:

/*SendToken(prev_mode == STILL?ZERO_STILL:BLOCK_SAME, channel, sub, oct, ctrl, h
ist, empty, branch); */
                SendToken(prev_mode == STILL ||
BlockZero(old)?ZERO_STILL:BLOCK_SAME, channel, sub, oct, ctrl, hist, empty, branch);
                break;
            case STILL:
            case SEND:
                active = True;

/*SendToken(prev_mode == STILL?NON_ZERO_STILL:BLOCK_CHANGE, channel, sub
, oct, ctrl, hist, empty, branch); */

```

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```

        SendToken(prev_mode == STILL ||
BlockZero(old)?NON_ZERO_STILL:BLOCK_CHANGE,channel,sub,oct,ctrl,hist,empty,
branch);

        UpdateCoeffs(pro,lev,addr,z,channel,oct,ctrl,hist);
        break;
    case VOID:
        SendToken(ZERO_VID,channel,sub,oct,ctrl,hist,empty,branch);
        ZeroCoeffs(ctrl->dst->data[channel][z],addr);
        break;
    }
} else {
    if (BlockZero(old)) new_mode=STOP;
    else {
        ZeroCoeffs(ctrl->dst->data[channel][z],addr);
        new_mode=VOID;
    }
}
if (oct > 0 && new_mode!=STOP) {
    int    mt=OCTAVE_EMPTY, full=FULL;

    Dprintf("x=%d, y=%d, oct=%d sub=%d mode
%d\n",x,y,oct,sub,new_mode);
    for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

(void)SendTree(new_mode,x*2+X,y*2+Y,z,oct-1,sub,channel,ctrl,hist,&mt,X+2*Y);
    if (mt==OCTAVE_EMPTY && new_mode!=VOID)
SendToken(OCT_ZERO,channel,sub,oct,ctrl,hist,&full,0);
}
return(active);
}

```

/\* Function Name: SendLPF

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- \* Description: Encode LPF sub-band
- \* Arguments: mode - compression mode
- \*                   z - frame number
- \*                   ctrl - compression control record
- \*                   hist - history records
- \* Returns: encodes data
- \*/

```
void SendLPF(mode,z,ctrl,hist)
```

```
CompCtrl ctrl;
```

```
int mode, z;
```

```
Hist hist;
```

```
{
```

```
Block new, old, pro, lev, addr;
```

```
int channel, channels=ctrl->src->type==MONO?1:3, x, y, full=FULL,
```

```
octs_lum=ctrl->src->trans.wavelet.space[0],
```

```
size[2]={Size(ctrl->src,0,0)>>octs_lum+1,Size(ctrl->src,0,1)>>octs_lum+1};
```

```
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
```

```
int empty=LPF_EMPTY;
```

```
for(channel=0;channel<channels;channel++) {
```

```
int octs=ctrl->src->trans.wavelet.space[ctrl->src->type==YUV
```

```
&& channel!=0?1:0],
```

```
new_mode, X, Y, step, value, bits=0;
```

```
double
```

```
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};
```

```
CalcNormals(ctrl,octs-1,0,channel,norms);
```

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```

    step = norms[0] < 1.0 ? 1 : (int) norms[0];
    for(bits=0,
value=((1 < < 8 + ctrl->dst->precision)-1)/step; value != 0; bits++)
        value = value >> 1;
    ReadBlock(new, old, addr, x, y, z, octs-1, 0, channel, ctrl);

    /* Proposed */
    for(X=0; X < BLOCK; X++) for(Y=0; Y < BLOCK; Y++)

pro[X][Y] = old[X][Y] + Quantize(new[X][Y]-old[X][Y], step, &(lev[X][Y]));

    /* MakeDecisions */

new_mode = mode == STILL ? STILL : Decision(new, old, norms[2], ctrl->decide) ||
BlockZero(lev) ? STOP : SEND;

    switch(new_mode) {
    case SEND:
        SendToken(LPF_NON_ZERO, channel, 0, octs, ctrl.hist, &empty, 0);
        UpdateCoeffs(pro, lev, addr, z, channel, octs, ctrl, hist);
        break;
    case STILL:
        for(X=0; X < BLOCK; X++) for(Y=0; Y < BLOCK; Y++) {
            ctrl->dst->data[channel][z][addr[X][Y]] = (short)pro[X][Y];
            hist->bits += bits;
            hist->octbits[channel][octs] += bits;
            if (ctrl->bin_switch) {
                unsigned char *bytes = CodeInt(lev[X][Y], bits);

                bwrite(bytes, bits, ctrl->bfp);
                XtFree(bytes);
            }
        }
    }

```

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```

        }
        break;
    case STOP:
        SendToken(LPF_ZERO,channel,0,octs,ctrl,hist,&empty,0);
        break;
    }
}

if (mode!=STILL && empty==LPF_EMPTY)
SendToken(LPF_LOC_ZERO,channel,0,octs_lum,ctrl,hist,&full,0);
}

hist->lpf=hist->bits;
}

```

```

/*  Function Name:    LookAhead
 *  Description:    Examine base of tree to calculate new quantizer value
 *  Arguments:    z - frame number
 *                ctrl - compression control record
 *                hist - history records
 *  Returns:    calculates new ctrl->quant_const
 */

```

```
void LookAhead(z,ctrl,hist)
```

```
CompCtrl    ctrl;
```

```
int    z;
```

```
Hist    hist;
```

```
{
```

```

    int    x, y, sub, index, thresh[HISTO], decide=ctrl->decide, act,
           taract=Feedback(hist,z,ctrl->feedback),
           octs=ctrl->src->trans.wavelet.space[0],

```

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```

size[2] = {Size(ctrl->src,0,0) > > 1 + octs, Size(ctrl->src,0,1) > > 1 + octs};
    Block new, old, addr;
    double      old_quant = ctrl->quant_const;

    ctrl->quant_const = 1.0;
    for(index = 0; index < HISTO; index++) thresh[index] = 0;
    for(y = 0; y < size[1]; y++) for(x = 0; x < size[0]; x++)
for(sub = 1; sub < 4; sub++) {
        double      q_thresh[3],
norms[3] = {ctrl->quant_const, ctrl->thresh_const, ctrl->cmp_const};
        Block zero_block = {{0,0},{0,0}};

        ReadBlock(new, old, addr, x, y, z, octs-1, sub, 0, ctrl);
        CalcNormals(ctrl, octs-1, sub, 0, norms);

q_thresh[1] = (double)Decide(new, zero_block, decide)/DecideDouble(norms[1], decide);

q_thresh[2] = (double)Decide(new, old, decide)/DecideDouble(norms[2], decide);
        if (BlockZero(old)) q_thresh[0] = q_thresh[1];
        else q_thresh[0] = q_thresh[2] < q_thresh[1] ? q_thresh[2] : q_thresh[1];
        if (ctrl->decide == SIGSQR) q_thresh[0] = sqrt(q_thresh[0]);

index = (int)((q_thresh[0] - old_quant + HISTO_DELTA) * HISTO / (HISTO_DELTA * 2));
        index = index < 0 ? 0 : index > HISTO-1 ? HISTO-1 : index;
        thresh[index]++;
    }
    for(index = HISTO-1, act = 0; index >= 0 && act < taract; index--)
act += thresh[index];

ctrl->quant_const = (double)(index + 1) * HISTO_DELTA * 2.0 / HISTO + old_quant - HISTO_
DELTA;

ctrl->quant_const = ctrl->quant_const < 0.0 ? 0.0 : ctrl->quant_const;

```

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```

    Dprintf("Target bits %d act %d (real %d) adjust q_const to
    %3.2f\n", hist[z].target, taract, act, ctrl->quant_const);
    hist[z].q_const = ctrl->quant_const;
    ctrl->quant_const = Filter(hist, z, ctrl->feedback, ctrl->filter);
    Dprintf("Post filtering q_const to %3.2f\n", ctrl->quant_const);
    if (ctrl->bin_switch) {
        unsigned char *bytes = CodeInt(index + 1 - HISTO/2, HISTO_BITS);

        bwrite(bytes, HISTO_BITS, ctrl->bfp);
        XtFree(bytes);
    }
}

```

```

/*  Function Name:      CompressStats
 *  Description:        Compile compression statistics
 *  Arguments:          ctrl - compression control record
 *                      hist - history records
 *  Returns:            plot graphs
 */

```

```
void  CompressStats(ctrl, hist)
```

```
CompCtrl  ctrl;
```

```
Hist  hist;
```

```

{
    FILE  *fp_token, *fp_coeff, *fp_log, *fopen();
    char  file_name[STRLEN];
    int   channel, z, i, sigma;

```

```
sprintf(file_name, "%s%s/%s.token%s\0", global->home, PLOT_DIR, ctrl->stats_name, P
```



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LOT\_EXT);

fp\_token = fopen(file\_name, "w");

sprintf(file\_name, "%s%s/%s.coeff%s\0", global-&gt;home, PLOT\_DIR, ctrl-&gt;stats\_name, PL

OT\_EXT);

fp\_coeff = fopen(file\_name, "w");

sprintf(file\_name, "%s%s/%s.log%s\0", global-&gt;home, PLOT\_DIR, ctrl-&gt;stats\_name, PLO

T\_EXT);

fp\_log = fopen(file\_name, "w");

fprintf(fp\_token, "\nTokens %s\n", ctrl-&gt;name);

for(i=0; i &lt; TOKENS; i++) {

sigma=0;

for(z=0; z &lt; ctrl-&gt;src-&gt;size[2]; z++) sigma += hist[z].token[i];

fprintf(fp\_token, "%d %d\n", i, sigma);

}

fprintf(fp\_coeff, "\nCoeffs %s\n", ctrl-&gt;name);

for(i=0; i &lt; 129; i++) {

sigma=0;

for(z=0; z &lt; ctrl-&gt;src-&gt;size[2]; z++) sigma += hist[z].coeff[i];

fprintf(fp\_coeff, "%d %d\n", i, sigma);

}

for(i=0; i &lt; 5; i++) {

String titles[5] = {"treebits", "activity", "quant", "bits", "ratio"};

fprintf(fp\_log, "\n\n%s\n", titles[i]);

for(z=0; z &lt; ctrl-&gt;src-&gt;size[2]; z++)

switch(i) {

case 0: fprintf(fp\_log, "%d %d\n", z, hist[z].bits-hist[z].lpf);

break;

case 1: fprintf(fp\_log, "%d %d\n", z, hist[z].activity);

break;

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```

        case 2: fprintf(fp_log, "%d %f\n", z, hist[z].q_const);
                break;

        case 3:  fprintf(fp_log, "%d %d\n", z, hist[z].bits);
                break;

        case 4:  fprintf(fp_log, "%d
%f\n", z, (double)(hist[z].bits - (z == 0 ? hist[z].lpf : 0)) / (double)hist[z].activity);
                break;

    }

}

for(channel=0; channel < (ctrl->src->type == MONO ? 1 : 3); channel++) {
    int    octs = ctrl->src->trans.wavelet.space[ctrl->src->type == YUV
&& channel != 0 ? 1 : 0];

    for(i=0; i <= octs; i++) {
        fprintf(fp_log, "\n\channel %d oct %d\n", channel, i);
        for(z=0; z < ctrl->src->size[2]; z++)
            fprintf(fp_log, "%d %d\n", z, hist[z].octbits[channel][i]);
    }
}

fclose(fp_token); fclose(fp_coeff); fclose(fp_log);
}

```

```

/*  Function Name:    CopyFrame
*   Description:    Copy frame or zero
*   Arguments:    vid - video
*                  from, to - source and destination frame numbers
*                  zero - zero out flag
*   Returns:    alters video->data
*/

```

```
void CopyFrame(vid, from, to, zero)
```

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```

Video vid;
int    from, to;
Boolean    zero;

{
    int    i, channel;

    for(channel=0;channel < (vid->type == MONO?1:3);channel++) {
        int    size = Size(vid,channel,0)*Size(vid,channel,1);

        for(i=0;i < size;i++)
            vid->data[channel][to][i] = zero?0:vid->data[channel][from][i];
    }
}

```

```

/*    Function Name:    CompressFrame
 *    Description:    Compress a Frame
 *    Arguments:    ctrl - compression control record
 *                  z - frame number
 *                  hist - history records
 *                  target - target bits
 */

```

```

void    CompressFrame(ctrl,z,hist,target)

```

```

CompCtrl    ctrl;
int    z, target;
Hist    hist;

{
    Video src=ctrl->src, dst=ctrl->dst;
    int    sub, channel, x, y, mode=ctrl->stillvid || z==0?STILL:SEND.

```

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```

        octs_lum = src->trans.wavelet.space[0],

size[2] = {Size(src,0,0) > 1 + octs_lum, Size(src,0,1) > 1 + octs_lum};

NewFrame(dst,z);
CopyFrame(dst,z-1,z,ctrl->stillvid || z==0);
GetFrame(src,z);
hist[z].target=target;
if (z!=0 && ctrl->auto_q) LookAhead(z,ctrl,hist);
SendLPF(mode,z,ctrl,&hist[z]);
Dprintf("LPF bits %d\n",hist[z].lpf);
hist[z].q_const=ctrl->quant_const;
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
    int    empty=EMPTY, full=FULL;

    for(channel=0;channel<(dst->type==MONO?1:3);channel++) {
        int    octs=src->trans.wavelet.space[src->type==YUV &&
channel!=0?1:0];

        for(sub=1;sub<4;sub++) {
            Boolean
active=SendTree(mode,x,y,z,octs-1,sub,channel,ctrl,&hist[z],&empty,0);

            hist[z].activity+=channel==0 && active;
        }
        switch(empty) {
        case FULL:
            empty=CHANNEL_EMPTY;
            break;
        case CHANNEL_EMPTY:
            SendToken(CHANNEL_ZERO,channel,sub,octs-1,ctrl,&hist[z],&full,0);
            break;

```

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```

        }
    }
    if (empty == EMPTY)
        SendToken(LOCAL_ZERO,channel,sub,octs_lum-1,ctrl,&hist[z],&full,0);
    }
    Dprintf("Activity: %d\n",hist[z].activity);
    FreeFrame(src,z);
}

```

```

/*  Function Name:    SkipFrame
    *  Description:    Shuffle frame data as if current frame was skipped
    *  Arguments:     vid - video
    *                  z - frame number
    *  Returns:        alters vid->data
    */

```

```
void  SkipFrame(vid,z)
```

```
Video vid;
```

```
int    z;
```

```

{
    NewFrame(vid,z);
    CopyFrame(vid,z-1,z,False);
    if (z > 1) {
        GetFrame(vid,z-2);
        CopyFrame(vid,z-2,z-1,False);
        FreeFrame(vid,z-2);
    }
}

```

```
/*  Function Name:    CompressCtrl
```

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- Description: Perform KLICS on a video
- Arguments: w - Xaw widget
- closure - compression control record
- call\_data - NULL
- Returns: compressed video
- /\*

```
void CompressCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    CompCtrl  ctrl=(CompCtrl)closure;
```

```
    int       sigma_bits, frame_count, z, i, buffer=0, frames=ctrl->src->size[2],
```

```
             bpf_in=(64000*ctrl->bitrate)/ctrl->src->rate,
```

```
             bpf_out=(int)((double)(64000*ctrl->bitrate)/ctrl->fps);
```

```
    FILE      *fopen();
```

```
    char      file_name[STRLEN];
```

```
    HistRec   hist[frames];
```

```
    Message   msg=NewMessage(NULL,60);
```

```
    msg->rows=frames>10?11:frames+(frames==1?0:1); msg->cols=30;
```

```
    if (global->batch==NULL) {
```

```
        XtCallbackRec  callbacks[]={
```

```
            {CloseMessage,(caddr_t)msg}, {NULL,NULL},
```

```
        };
```

```
    MessageWindow(FindWidget("frm_compress",w),msg,"KLICS",True,callbacks);
```

```
    }
```

```
    Dprintf("CompressCtrl\n");
```

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```

    if (ctrl->src->type == YUV &&
(ctrl->src->trans.wavelet.space[0] != ctrl->src->trans.wavelet.space[1] + ctrl->src->U
Vsample[0] || ctrl->src->UVsample[0] != ctrl->src->UVsample[1])) {
        Eprintf("Y-UV octaves mis-matched. Check UV-sample");
        return;
    }
    ctrl->dst = CopyHeader(ctrl->src);
    strcpy(ctrl->dst->name, ctrl->name);
    if (ctrl->dst->disk) SaveHeader(ctrl->dst);
    if (ctrl->bin_switch) {

sprintf(file_name, "%s%s/%s%s\0", global->home, KLICS_DIR, ctrl->bin_name, KLICS_
EXT);

        ctrl->bfp = bopen(file_name, "w");
        /* Write some sort of header */
        WriteKlicsHeader(ctrl);
    }
    for(z=0; z < frames; z++) {
        hist[z].bits = 0;
        hist[z].lpf = 0;
        hist[z].activity = 0;
        hist[z].target = 0;
        for(i=0; i < 5; i++) hist[z].octbits[0][i] = 0;
        for(i=0; i < 5; i++) hist[z].octbits[1][i] = 0;
        for(i=0; i < 5; i++) hist[z].octbits[2][i] = 0;
        for(i=0; i < TOKENS; i++) hist[z].token[i] = 0;
        for(i=0; i < 129; i++) hist[z].coeff[i] = 0;
        hist[z].q_const = 0.0;
    }
    for(z=0; z < frames; z++) {
        if (z == 0 || !ctrl->buf_switch) {
            CompressFrame(ctrl, z, hist, bpf_out);

```

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```

        buffer = 3200*ctrl-> bitrate + bpf_in;
    } else {
        Boolean    no_skip;

        buffer -= bpf_in;
        buffer = buffer < 0 ? 0 : buffer;
        no_skip = buffer < 6400*ctrl-> bitrate; /* H.261 buffer size */
        if (ctrl-> bin_switch) bwrite(&no_skip, 1, ctrl-> bfp);
        if (no_skip) {
            CompressFrame(ctrl, z, hist, bpf_out/* + bpf_out/2 - buffer */);
            buffer += hist[z].bits;
        } else SkipFrame(ctrl-> dst, z);
    }
    if (z > 0) {
        SaveFrame(ctrl-> dst, z-1);
        FreeFrame(ctrl-> dst, z-1);
    }
    Mprintf(msg, "%s%03d: %d
bits\n", ctrl-> dst-> name, z + ctrl-> src-> start, hist[z].bits);
    Mflush(msg);
}
SaveFrame(ctrl-> dst, ctrl-> src-> size[2]-1);
FreeFrame(ctrl-> dst, ctrl-> src-> size[2]-1);
if (ctrl-> bin_switch) { bflush(ctrl-> bfp); bclose(ctrl-> bfp); }
if (ctrl-> stats_switch) CompressStats(ctrl, hist);
Dprintf("Compression Complete\n");
sigma_bits = 0, frame_count = 0;
for (z = 0; z < ctrl-> src-> size[2]; z++) {
    sigma_bits += hist[z].bits;
    if (hist[z].bits != 0) frame_count++;
}
if (ctrl-> buf_switch) {

```



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```

        Dprintf("Buffer contains %d bits\n",buffer-bpf_in);
        Dprintf("Frame Rate %4.1f
Hz\n",(double)(ctrl->src->rate*(frame_count-1))/(double)(ctrl->src->size[2]-1));
    }
    if (frames > 1) {
        Mprintf(msg,"Total: %d bits\n",sigma_bits);
        Mflush(msg);
    }
    ctrl->dst->next=global->videos;
    global->videos=ctrl->dst;
}

/*  Function Name:      BatchCompCtrl
 *  Description:  Batch interface to CompressCtrl
 */

void  BatchCompCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    CompCtrl  ctrl=(CompCtrl)closure;

    if (ctrl->src == NULL) ctrl->src=FindVideo(ctrl->src_name,global->videos);
    CompressCtrl(w,closure,call_data);
}

/*  Function Name:      InitCompCtrl
 *  Description:  Initialise the compression control record
 *  Arguments:  name - name of the source video
 *  Returns:    compression control record

```

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\*/

CompCtrl InitCompCtrl(name)

String name;

{

CompCtrl ctrl=(CompCtrl)MALLOC(sizeof(CompCtrlRec));

int i;

ctrl-&gt;decide = SIGABS;

ctrl-&gt;feedback=4;

ctrl-&gt;filter=0;

ctrl-&gt;stillvid=True;

ctrl-&gt;stats\_switch=False;

ctrl-&gt;auto\_q=True;

ctrl-&gt;buf\_switch=True;

ctrl-&gt;bin\_switch=False;

ctrl-&gt;cmp\_const=0.9;

ctrl-&gt;thresh\_const=0.6;

ctrl-&gt;quant\_const=8.0;

ctrl-&gt;fps=30.0;

ctrl-&gt;bitrate=1;

for(i=0;i&lt;5;i++) {

double defaults[5]={1.0,0.32,0.16,0.16,0.16};

ctrl-&gt;base\_factors[i]=defaults[i];

}

ctrl-&gt;diag\_factor=1.4142136;

ctrl-&gt;chrome\_factor=2.0;

strcpy(ctrl-&gt;src\_name,name);

strcpy(ctrl-&gt;name.name);

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```

        strcpy(ctrl->stats_name,name);
        strcpy(ctrl->bin_name,name);
        return(ctrl);
    }

/*    Function Name:    Compress
 *    Description:    X Interface to CompressCtrl
 */

#define    COMP_ICONS    25
#define    VID_ICONS    15

void    Compress(w,closure,call_data)

Widget        w;
caddr_t        closure, call_data;

{
    Video    video=(Video)closure;
    CompCtrl    ctrl=InitCompCtrl(video->name);
    int    i, space=video->trans.wavelet.space[0]+1;
    NumInput    num_inputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    FloatInput    flt_inputs=(FloatInput)MALLOC(6*sizeof(FloatInputRec)),

oct_inputs=(FloatInput)MALLOC(space*sizeof(FloatInputRec));
    Message    msg=NewMessage(ctrl->name,NAME_LEN),
                msg_bin=NewMessage(ctrl->bin_name,NAME_LEN),
                msg_stats=NewMessage(ctrl->stats_name,NAME_LEN);
    XtCallbackRec    destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)num_inputs},
        {Free,(caddr_t)flt_inputs},

```

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```

        {Free,(caddr_t)oct_inputs},
        {CloseMessage,(caddr_t)msg},
        {CloseMessage,(caddr_t)msg_bin},
        {CloseMessage,(caddr_t)msg_stats},
        {NULL,NULL},
    };

    Widget      parent = FindWidget("frm_compress",XtParent(w)),
               shell = ShellWidget("klics",parent,SW_below,NULL,destroy_call),
               form = FormatWidget("klics_form",shell),

    dec_shell = ShellWidget("klics_cng_dec",shell,SW_menu,NULL,NULL), dec_widgets[3],

    filt_shell = ShellWidget("klics_cng_filt",shell,SW_menu,NULL,NULL), filt_widgets[2],
               widgets[COMP_ICONS], vid_widgets[VID_ICONS],
    oct_widgets[space*2];

    FormItem    items[] = {
        {"klics_cancel","cancel",0,0,FW_icon,NULL},
        {"klics_confirm","confirm",1,0,FW_icon,NULL},
        {"klics_title","Compress a video",2,0,FW_label,NULL},
        {"klics_vid_lab","Video Name:",0,3,FW_label,NULL},
        {"klics_vid",NULL,4,3,FW_text,(String)msg},

        {"klics_stats_lab","Statistics:",0,4,FW_label,NULL},
        {"klics_stats",NULL,4,4,FW_yn,(String)&ctrl->stats_switch},
        {"klics_stats_name",NULL,7,4,FW_text,(String)msg_stats},
        {"klics_bin_lab","KLICS File:",0,6,FW_label,NULL},
        {"klics_bin",NULL,4,6,FW_yn,(String)&ctrl->bin_switch},

        {"klics_bin_name",NULL,10,6,FW_text,(String)msg_bin},
        {"klics_dec_lab","Decision:",0,9,FW_label,NULL},
        {"klics_dec_btn","SigmaAbs",4,9,FW_button,"klics_cng_dec"},
        {"klics_qn_float",NULL,0,12,FW_float,(String)&flt_inputs[0]},
    }

```

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```

{"klics_qn_scroll",NULL,4,12,FW_scroll,(String)&flt_inputs[0]},

{"klics_th_float",NULL,0,14,FW_float,(String)&flt_inputs[1]},
{"klics_th_scroll",NULL,4,14,FW_scroll,(String)&flt_inputs[1]},
{"klics_cm_float",NULL,0,16,FW_float,(String)&flt_inputs[2]},
{"klics_cm_scroll",NULL,4,16,FW_scroll,(String)&flt_inputs[2]},
{"klics_ch_float",NULL,0,18,FW_float,(String)&flt_inputs[3]},

{"klics_ch_scroll",NULL,4,18,FW_scroll,(String)&flt_inputs[3]},
{"klics_di_float",NULL,0,20,FW_float,(String)&flt_inputs[4]},
{"klics_di_scroll",NULL,4,20,FW_scroll,(String)&flt_inputs[4]},
{"klics_oct_form",NULL,0,22,FW_form,NULL},
{"klics_vid_form",NULL,0,24,FW_form,NULL},
}, vid_items[]={
{"klics_ic_lab","Image Comp:",0,0,FW_label,NULL},
{"klics_ic",NULL,1,0,FW_yn,(String)&ctrl->stillvid},
{"klics_tg_float",NULL,0,1,FW_float,(String)&flt_inputs[5]},
{"klics_tg_scroll",NULL,1,1,FW_scroll,(String)&flt_inputs[5]},
{"klics_px_int",NULL,0,3,FW_integer,(String)&num_inputs[0]},

{"klics_px_down",NULL,1,3,FW_down,(String)&num_inputs[0]},
{"klics_px_up",NULL,6,3,FW_up,(String)&num_inputs[0]},
{"klics_auto_lab","Auto Quant:",0,5,FW_label,NULL},
{"klics_auto",NULL,1,5,FW_yn,(String)&ctrl->auto_q},
{"klics_buf_lab","Buffer:",0,8,FW_label,NULL},

{"klics_buf",NULL,1,8,FW_yn,(String)&ctrl->buf_switch},
{"klics_buf_btn","None",11,8,FW_button,"klics_cng_filt"},
{"klics_hs_int",NULL,0,10,FW_integer,(String)&num_inputs[1]},
{"klics_hs_down",NULL,1,10,FW_down,(String)&num_inputs[1]},
{"klics_hs_up",NULL,14,10,FW_up,(String)&num_inputs[1]},
}, oct_items[2*space];

```

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```

MenuItem    dec_menu[] = {
    {"klics_dec_max", smeBSBObjectClass, "Maximum", NULL},
    {"klics_dec_abs", smeBSBObjectClass, "SigmaAbs", NULL},
    {"klics_dec_sqr", smeBSBObjectClass, "SigmaSqr", NULL},
}, filt_menu[] = {
    {"klics_filt_none", smeBSBObjectClass, "None", NULL},
    {"klics_filt_exp", smeBSBObjectClass, "Exp", NULL},
};

XtCallbackRec    callbacks[] = {
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {CompressCtrl, (caddr_t)ctrl},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->stats_switch}, {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->bin_switch}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[0]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[1]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[2]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[3]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[4]}, {NULL, NULL},
}, vid_call[] = {
    {ChangeYN, (caddr_t)&ctrl->stillvid}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[5]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->auto_q}, {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->buf_switch}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
}, dec_call[] = {
    {SimpleMenu, (caddr_t)&ctrl->decide}, {NULL, NULL},

```

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```
{ SimpleMenu, (caddr_t)&ctrl->decide}, {NULL, NULL},
{ SimpleMenu, (caddr_t)&ctrl->decide}, {NULL, NULL},
}, flt_call[] = {
{ SimpleMenu, (caddr_t)&ctrl->filter}, {NULL, NULL},
{ SimpleMenu, (caddr_t)&ctrl->filter}, {NULL, NULL},
}, oct_call[2*space];
XFontStruct *font;
Arg args[1];

msg->rows = 1; msg->cols = NAME_LEN;
msg_stats->rows = 1; msg_stats->cols = NAME_LEN;
msg_bin->rows = 1; msg_bin->cols = NAME_LEN;
ctrl->src = (Video)closure;

flt_inputs[0].format = "Quant: %4.1f";
flt_inputs[0].max = 10;
flt_inputs[0].min = 0;
flt_inputs[0].value = &ctrl->quant_const;

flt_inputs[1].format = "Thresh: %4.1f";
flt_inputs[1].max = 10;
flt_inputs[1].min = 0;
flt_inputs[1].value = &ctrl->thresh_const;

flt_inputs[2].format = "Comp: %4.1f";
flt_inputs[2].max = 10;
flt_inputs[2].min = 0;
flt_inputs[2].value = &ctrl->cmp_const;

flt_inputs[3].format = "Chrome: %4.1f";
flt_inputs[3].max = 5;
flt_inputs[3].min = 1;
```

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```
flt_inputs[3].value = &ctrl->chrome_factor;
```

```
flt_inputs[4].format = "Diag: %4.1f";
```

```
flt_inputs[4].max = 2.0;
```

```
flt_inputs[4].min = 1.0;
```

```
flt_inputs[4].value = &ctrl->diag_factor;
```

```
flt_inputs[5].format = "Target: %4.1f";
```

```
flt_inputs[5].max = 30.0;
```

```
flt_inputs[5].min = 10.0;
```

```
flt_inputs[5].value = &ctrl->fps;
```

```
num_inputs[0].format = "px64k: %1d";
```

```
num_inputs[0].max = 8;
```

```
num_inputs[0].min = 1;
```

```
num_inputs[0].value = &ctrl->bitrate;
```

```
num_inputs[1].format = "History: %1d";
```

```
num_inputs[1].max = 8;
```

```
num_inputs[1].min = 1;
```

```
num_inputs[1].value = &ctrl->feedback;
```

```
for(i=0; i < space; i++) {
```

```
    String format = (char *)MALLOC(20);
```

```
    if (i == 0) sprintf(format, "Octave LPF: % %4.2f");
```

```
    else sprintf(format, "Octave %3d: % %4.2f", space-i-1);
```

```
    oct_inputs[i].format = format;
```

```
    oct_inputs[i].max = 1.0;
```

```
    oct_inputs[i].min = 0.0;
```

```
    oct_inputs[i].value = &ctrl->base_factors[space-i-1];
```

```
    oct_items[2*i].name = "klics_oct_float";
```



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```

    oct_items[2*i].contents=NULL;
    oct_items[2*i].fromHoriz=0;
    oct_items[2*i].fromVert=i==0?0:2*i-1;
    oct_items[2*i].type=FW_float;
    oct_items[2*i].hook=(String)&oct_inputs[i];
    oct_items[2*i+1].name="klics_oct_scroll";
    oct_items[2*i+1].contents=NULL;
    oct_items[2*i+1].fromHoriz=1;
    oct_items[2*i+1].fromVert=i==0?0:2*i-1;
    oct_items[2*i+1].type=FW_scroll;
    oct_items[2*i+1].hook=(String)&oct_inputs[i];
    oct_call[2*i].callback=FloatIncDec;
    oct_call[2*i].closure=(String)&oct_inputs[i];
    oct_call[2*i+1].callback=NULL;
    oct_call[2*i+1].closure=NULL;
}
FillForm(form,COMP_ICONS-(video->size[2]>1?0:1),items,widgets,callbacks);
FillForm(widgets[23],2*space,oct_items,oct_widgets,oct_call);
FillMenu(dec_shell,THREE,dec_menu,dec_widgets,dec_call);
font=FindFont(widgets[12]);

XtSetArg(args[0],XtNwidth,2+TextWidth(0,"Maximum\nSigmaAbs\nSigmaSqr",font));
XtSetValues(widgets[12],args,ONE);
if (video->size[2]>1) {
    FillForm(widgets[24],VID_ICONS,vid_items,vid_widgets,vid_call);
    FillMenu(filt_shell,TWO,filt_menu,filt_widgets,filt_call);
    font=FindFont(vid_widgets[11]);
    XtSetArg(args[0],XtNwidth,2+TextWidth(0,"None\nExp",font));
    XtSetValues(vid_widgets[11],args,ONE);
}
XtPopup(shell,XtGrabExclusive);
}

```

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source/KlicsSA.c

/\*

Full still/video Knowles-Lewis Image Compression System utilising HVS  
properties  
and delta-tree coding

Stand-Alone version uses fixed image format and static data structures

\*/

#include "KlicsSA.h"

#include &lt;math.h&gt;

extern void Convolve();

/\* useful X definitions \*/

typedef char Boolean;

#define True 1

#define False 0

#define String char\*

/\* token modes (empty) \*/

#define EMPTY 0

#define CHANNEL\_EMPTY 1

#define OCTAVE\_EMPTY 2

#define LPF\_EMPTY 3

#define FULL 4

/\* Function Name: AccessSA

\* Description: Find index address from co-ordinates

\* Arguments: x, y - (x,y) co-ordinates

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- \* oct, sub, channel - octave, sub-band and channel co-ordinates
- \* Returns: index into data[channel][index]
- \*/

```
int AccessSA(x,y,oct,sub,channel)
```

```
int x, y, oct, sub, channel;
```

```
{
```

```
return(((x < < 1)+(sub > > 1)+(SA_WIDTH > > (channel == 0?0:1))*((y < < 1)+(1&sub)
))< < oct);
```

```
}
```

```
/* Function Name: DecideSA
```

```
* Description: Calculate value representing the difference between new and old
blocks
```

- \* Arguments: new, old - blocks to compare
- \* Returns: difference value
- \*/

```
int DecideSA(new,old)
```

```
Block new, old;
```

```
{
```

```
int X, Y, sigma=0;
```

```
for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
```

```
sigma += abs(new[X][Y]-old[X][Y]);
```

```
return(sigma);
```

```
}
```

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```
/*  Function Name:    DecideDoubleSA
 *  Description:      Calculates normal w.r.t differencing algorithm
 *  Arguments:        norm - normal value
 *  Returns:          new normal value
 */
```

```
double    DecideDoubleSA(norm)
```

```
double    norm;
```

```
{
    return(4.0*norm);
}
```

```
Boolean    DecisionSA(new,old,norm)
```

```
Block new, old;
```

```
double    norm;
```

```
{
    return(((double)DecideSA(new,old) <= DecideDoubleSA(norm)));
}
```

```
/*  Function Name:    HuffmanSA
 *  Description:      Calculates the number of bits for the Huffman code representing
level
 *  Arguments:        level - level to be encoded
 *  Returns:          number of bits in codeword
 */
```

```
int    HuffmanSA(level)
```

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```
int    level;
```

```
{
    return(level == 0?2:(abs(level) < 3?3:1 + abs(level)));
}
```

```
/*    Function Name:    HuffCodeSA
 *    Description:    Generates Huffman code representing level
 *    Arguments:    level - level to be encoded
 *    Returns:    coded bits in char's
 */
```

```
unsigned char *HuffCodeSA(level)
```

```
int    level;
```

```
{
    unsigned char *bytes=(unsigned char *)MALLOC((7+Huffman(level))/8);

    bytes[0]=(abs(level) < 3?abs(level):3) | (level < 0?4:0);
    if (abs(level) > 2) {
        int    index=(7+Huffman(level))/8-1;

        bytes[index]=bytes[index] | (1 << (Huffman(level)-1)%8);
    }
    return(bytes);
}
```

```
unsigned char *CodeIntSA(number,bits)
```

```
int    number, bits;
```

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```

{
    int    len=(7+bits)/8;
    unsigned char *bytes=(unsigned char *)MALLOC(len);
    int    byte;

    for(byte=0;byte<len;byte++) {
        bytes[byte]=0xff&number;
        number=number>>8;
    }
    return(bytes);
}

```

```

int    ReadIntSA(bits,bfp)

```

```

int    bits;

```

```

Bits    bfp;

```

```

{
    int    len=(7+bits)/8;
    unsigned char bytes[len];
    int    byte, number=0;

    bread(bytes,bits,bfp);
    for(byte=0;byte<len;byte++)
        number=number|((int)bytes[byte]<<byte*8);
    number=(number<<sizeof(int)*8-bits)>>sizeof(int)*8-bits;
    return(number);
}

```

```

/* Function Name:    HuffReadSA

```

```

* Description:    Read Huffman encoded number from binary file

```

```

* Arguments:    bfp - binary file pointer

```

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\* Returns: decoded level

\*/

int HuffReadSA(bfp)

Bits bfp;

{

int value;

unsigned char byte;

Boolean negative = False;

bread(&byte, 2, bfp);

value = (int)byte;

if (byte == '\0') return(0);

else {

bread(&byte, 1, bfp);

negative = (byte != '\0');

}

if (value < 3) return(negif(negative, value));

for(byte = '\0'; byte != '\0'; value++) bread(&byte, 1, bfp);

return(negif(negative, value-1));

}

/\* Function Name: QuantizeSA

\* Description: RM8 style quantizer

\* Arguments: data - unquantised number

\* q - quantizing divisor

\* level - quantised to level

\* Returns: quantized data & level

\*/

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```

int    QuantizeSA(data.q,level)

int    data, q, *level;

{
    int    mag_level=abs(data)/q;

    *level=negif(data<0,mag_level);
    return(negif(data<0,mag_level*q+(mag_level!=0?(q-1)>>1:0)));
}

```

```

/*    Function Name:    ProposedSA
*    Description:    Calculates proposed block values
*    Arguments:    pro - proposed block
*                   lev - proposed block quantized levels
*                   old, new - old and new block values
*                   norms - HVS normals
*    Returns:    new==0, proposed values (pro) and levels (lev)
*/

```

```

Boolean    ProposedSA(pro,lev,old,new,norms)

```

```

Block pro, lev, old, new;

```

```

double    norms[3];

```

```

{
    Block zero_block={{0,0},{0,0}};
    int    X, Y, step=norms[0]<1.0?1:(int)norms[0];
    Boolean    zero=DecisionSA(new,zero_block,norms[1]);

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

```



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```

pro[X][Y] = zero?0:old[X][Y] + Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));
    return(zero);
}

```

```

/*  Function Name:    ZeroCoeffsSA
 *  Description:      Zero out video data
 *  Arguments:        data - image data
 *                    addr - addresses
 *  Returns:          zeros data[addr[]]
 */

```

```

void  ZeroCoeffsSA(data,addr)

```

```

short *data;
Block addr;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        data[addr[X][Y]]=0;
}

```

```

/*  Function Name:    BlockZeroSA
 *  Description:      Test if all block values are zero
 *  Arguments:        block - block under test
 *  Returns:          block == 0
 */

```

```

Boolean    BlockZeroSA(block)

```

```

Block block;

```

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```

{
    int    X, Y;
    Boolean    zero = True;

    for(X=0; X < BLOCK; X++) for(Y=0; Y < BLOCK; Y++)
        if (block[X][Y] != 0) zero = False;
    return(zero);
}

```

```

/*  Function Name:    SendTokenSA
    *  Description:    Increments token frequency
    *  Arguments:    token - token to be transmitted
    *                  channel, sub, oct - co-ordinates
    *                  bfp - binary file pointer
    *                  empty - zero state {EMPTY | CHANNEL_EMPTY |
OCTAVE_EMPTY | LPF_EMPTY | FULL}
    *                  branch - branch of tree (0-3)
    *  Returns:        encodes token
    */

```

```

void    SendTokenSA(token, channel, sub, oct, bfp, empty, branch)

```

```

int    token, channel, sub, oct, *empty, branch;
Bits    bfp;

```

```

{
    int    full = FULL, i;
    String
token_name[TOKENS] = {"ZERO_STILL", "NON_ZERO_STILL", "BLOCK_SAME", "ZE
RO_VID", "BLOCK_CHANGE",

"LOCAL_ZERO", "LOCAL_NON_ZERO", "CHANNEL_ZERO", "CHANNEL_NON_ZE

```

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RO", "OCT\_ZERO", "OCT\_NON\_ZERO",

"LPF\_ZERO", "LPF\_NON\_ZERO", "LPF\_LOC\_ZERO", "LPF\_LOC\_NON\_ZERO"};

```

switch(*empty) {
case EMPTY:
    if (token != ZERO_STILL && token != BLOCK_SAME) {

SendTokenSA(LOCAL_NON_ZERO, channel, sub, oct, bfp, &full, branch);
        for(i=0; i < channel; i++)

SendTokenSA(CHANNEL_ZERO, i, sub, oct, bfp, &full, branch);
            *empty = CHANNEL_EMPTY;
            SendTokenSA(token, channel, sub, oct, bfp, empty, branch);
        }
        break;
case CHANNEL_EMPTY:
    if (token != ZERO_STILL && token != BLOCK_SAME) {

SendTokenSA(CHANNEL_NON_ZERO, channel, sub, oct, bfp, &full, branch);
        for(i=1; i < sub; i++)

SendTokenSA(token == NON_ZERO_STILL ? ZERO_STILL : BLOCK_SAME, channel, i, oct, bfp, &full, branch);
            *empty = FULL;
            SendTokenSA(token, channel, sub, oct, bfp, empty, branch);
        }
        break;
case OCTAVE_EMPTY:
    if (token != ZERO_STILL && token != BLOCK_SAME) {

SendTokenSA(OCT_NON_ZERO, channel, sub, oct, bfp, &full, branch);
        for(i=0; i < branch; i++)

SendTokenSA(token == NON_ZERO_STILL ? ZERO_STILL : BLOCK_SAME, channel, sub

```

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```

.oct,bfp,&full,branch);
        *empty = FULL;
        SendTokenSA(token,channel,sub,oct,bfp,empty,branch);
    }
    break;
case LPF_EMPTY:
    if (token != LPF_ZERO) {

SendTokenSA(LPF_LOC_NON_ZERO,channel,sub,oct,bfp,&full,branch);
        for(i=0;i < channel;i++)
SendTokenSA(LPF_ZERO,i,sub,oct,bfp,&full,branch);
        *empty = FULL;
        SendTokenSA(token,channel,sub,oct,bfp,empty,branch);
    }
    break;
case FULL:
    Dprintf("%s\n",token_name[token]);
    bwrite(&token_codes[token],token_bits[token],bfp);
    break;
}
}

```

```

/*  Function Name:    ReadBlockSA
*   Description:     Read block from video
*   Arguments:      new, old, addr - new and old blocks and addresses
*                   x, y, oct, sub, channel - co-ordinates of block
*                   src, dst - frame data
*   Returns:        block values
*/

```

```

void  ReadBlockSA(new,old,addr,x,y,oct,sub,channel,src,dst)

```

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```

Block new, old, addr;
int    x, y, oct, sub, channel;
short  *src[3], *dst[3];

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        addr[X][Y]=AccessSA((x<<1)+X,(y<<1)+Y,oct,sub,channel);
        new[X][Y]=(int)src[channel][addr[X][Y]];
        old[X][Y]=(int)dst[channel][addr[X][Y]];
    }
}

```

```

/*  Function Name:    CalcNormalsSA
    *  Description:   Calculates HVS weighted normals
    *  Arguments:    oct, sub, channel - co-ordinates
    *                  norms - pre-initialised normals
    *  Returns:      weighted normals
*/

```

```

void  CalcNormalsSA(oct,sub,channel,norms,quant_const)

int    oct, sub, channel;
double  norms[3], quant_const;

{
    int    norm, base_oct=oct+(channel!=0?1:0)+(sub==0?1:0);

    for(norm=0;norm<3;norm++) {
        if (norm!=0) norms[norm] *= quant_const;
        norms[norm] *= base_factors[base_oct]*(sub==3?diag_factor:1.0);
    }
}

```

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```

        if (channel!=0) norms[norm] *= chrome_factor;
        norms[norm] *=(double)(1 < < SA_PRECISION);
    }
}

/*  Function Name:      MakeDecisions2SA
 *  Description:  Decide on new compression mode from block values
 *  Arguments:    old, new, pro - block values
 *               zero - zero flag for new block
 *               norms - HVS normals
 *               mode - current compression mode
 *               decide - comparison algorithm
 *  Returns:      new compression mode
 */

int  MakeDecisions2SA(old,new,pro,lev,zero,norms,mode)

Block  new, old, pro, lev;
Boolean  zero;
double  norms[3];
int  mode;

{
    Block  zero_block={{0,0},{0,0}};
    int  new_mode=mode==STILL || BlockZeroSA(old)?STILL:SEND,
        np=DecideSA(new,pro), no=DecideSA(new,old);

    if (new_mode==STILL) new_mode=np>=no || zero ||
BlockZeroSA(lev)?STOP:STILL;
    else new_mode=zero && np<no?VOID:np>=no ||
DecisionSA(new,old,norms[2]) || BlockZeroSA(lev)?STOP:SEND;
    return(new_mode);
}

```

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}

```

/*  Function Name:      UpdateCoeffsSA
 *
 *  Description:  Encode proposed values and write data
 *
 *  Arguments:   pro, lev, addr - proposed block, levels and addresses
 *
 *               channel, oct - co-ordinates
 *
 *               dst - destination data
 *
 *               bfp - binary file pointer
 *
 *  Returns:     alters dst[channel][addr[]]
 */

```

```

void  UpdateCoeffsSA(pro,lev,addr,channel,oct,dst,bfp)

```

```

Block  pro, lev, addr;

```

```

int    channel, oct;

```

```

short  *dst[3];

```

```

Bits   bfp;

```

```

{

```

```

    int    X, Y;

```

```

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {

```

```

        int    bits=HuffmanSA(lev[X][Y]),

```

```

            level=abs(lev[X][Y]);

```

```

        unsigned char    *bytes=HuffCodeSA(lev[X][Y]);

```

```

        dst[channel][addr[X][Y]]=(short)pro[X][Y];

```

```

        bwrite(bytes,bits,bfp);

```

```

        XtFree(bytes);

```

```

    }

```

```

}

```

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```

/*  Funcuon Name:      SendTreeSA
    •  Description:    Encode tree blocks
    •  Arguments:     prev_mode - compression mode
    •                  x, y, oct, sub, channel - co-ordinates
    •                  empty - token mode
    •                  branch - tree branch number
    •  Returns:       active block indicator
*/

```

Boolean

SendTreeSA(prev\_mode.x.y.oct.sub.channel.src.dst.empty.branch.quant\_const.bfp)

int prev\_mode, x, y, oct, sub, channel, \*empty, branch;

short \*src[3], \*dst[3];

double quant\_const;

Bits bfp;

{

Block addr, old, new, pro, lev;

int new\_mode, X, Y;

double norms[3]={quant\_const.thresh\_const.cmp\_const}; /\* quant. thresh.

compare \*/

Boolean active = False;

ReadBlockSA(new,old.addr.x.y.oct.sub.channel.src.dst);

if (prev\_mode != VOID) {

Boolean zero;

CalcNormalsSA(oct.sub.channel.norms.quant\_const);

zero = ProposedSA(pro,lev,old,new.norms);

new\_mode = MakeDecisions2SA(old,new.pro.lev.zero.norms.prev\_mode);

switch(new\_mode) {



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```

    case STOP:
        SendTokenSA(prev_mode == STILL ||
BlockZeroSA(old)?ZERO_STILL:BLOCK_SAME.channel.sub.oct.bfp.empty,branch);
        break;
    case STILL:
    case SEND:
        active = True;
        SendTokenSA(prev_mode == STILL ||
BlockZero(old)?NON_ZERO_STILL:BLOCK_CHANGE.channel.sub.oct.bfp.empty,bran
ch);

        UpdateCoeffsSA(pro,lev,addr,channel.oct,dst.bfp);
        break;
    case VOID:
        SendTokenSA(ZERO_VTD.channel.sub.oct.bfp.empty,branch);
        ZeroCoeffsSA(dst[channel],addr);
        break;
    }
} else {
    if (BlockZeroSA(old)) new_mode = STOP;
    else {
        ZeroCoeffsSA(dst[channel],addr);
        new_mode = VOID;
    }
}
if (oct > 0 && new_mode != STOP) {
    int    ml = OCTAVE_EMPTY, full = FULL;

    Dprintf("x = %d, y = %d, oct = %d sub = %d mode
%d\n",x,y,oct,sub,new_mode);
    for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

(void)SendTreeSA(new_mode.x*2+X.y*2+Y.oct-1,sub.channel.src,dst.&ml,X+2*Y,qua

```

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```

nt_const.bfp);
        if (mt == OCTAVE_EMPTY && new_mode != VOID)
SendTokenSA(OCT_ZERO, channel, sub, oct, bfp, &full, 0);
    }
    return(active);
}

```

```

/*  Function Name:      SendLPF_SA
 *  Description:      Encode LPF sub-band
 *  Arguments:      mode - compression mode
 *  Returns:      encodes data
 */

```

```

void  SendLPF_SA(mode, src, dst, bfp, quant_const)

```

```

int    mode;

```

```

short *src[3], *dst[3];

```

```

Bits   bfp;

```

```

double    quant_const;

```

```

{

```

```

    Block new, old, pro, lev, addr;

```

```

    int    channel, channels=3, x, y, full=FULL,

```

```

        octs_lum=3,

```

```

size[2]={SA_WIDTH>>octs_lum+1,SA_HEIGHT>>octs_lum+1};

```

```

    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {

```

```

        int    empty=LPF_EMPTY;

```

```

    for(channel=0;channel<channels;channel++) {

```

```

        int    octs=channel!=0?2:3.

```

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```

        new_mode, X, Y, step, value, bits=0;
double      norms[3]={quant_const.thresh_const.cmp_const};

CalcNormalsSA(octs-1,0,channel,norms,quant_const);
step=norms[0]<1.0?1:(int)norms[0];
for(bits=0, value=((1<<8+SA_PRECISION)-1)/step;value!=0;bits++)
    value=value>>1;
ReadBlockSA(new,old,addr,x,y,octs-1,0,channel,src,dst);

/* Proposed */
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=old[X][Y]+QuantizeSA(new[X][Y]-old[X][Y],step,&(lev[X][Y]));

/* MakeDecisions */
new_mode=mode==STILL?STILL:DecisionSA(new,old,norms[2])||
BlockZeroSA(lev)?STOP:SEND;

switch(new_mode) {
case SEND:
    SendTokenSA(LPF_NON_ZERO.channel,0,octs,bfp,&empty,0);
    UpdateCoeffsSA(pro,lev,addr,channel,octs,dst,bfp);
break:
case STILL:
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        unsigned char *bytes=CodeIntSA(lev[X][Y],bits);

        dst[channel][addr[X][Y]]=(short)pro[X][Y];
        bwrite(bytes,bits,bfp);
        XtFree(bytes);
    }
break:

```

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```

        case STOP:
            SendTokenSA(LPF_ZERO.channel.0.oct5.bfp.&empty,0);
            break;
        }
    }
    if (mode!= STILL && empty==LPF_EMPTY)
        SendTokenSA(LPF_LOC_ZERO.channel.0.oct5_lum.bfp.&full,0);
    }
}

```

```

/*  Function Name:    CompressFrameSA
 *  Description:      Compress a Frame
 *  Arguments:        mode - compression mode STILL or SEND
 *                      src, dst - source and destination data
 *                      bfp - binary file pointer for result
 *                      quant_const - quantization parameter
 */

```

```
void CompressFrameSA(mode,src,dst,bfp,quant_const)
```

```
int mode;
```

```
short *src[3], *dst[3];
```

```
Bits bfp;
```

```
double quant_const;
```

```
{
```

```
    int sub, channel, x, y, i,
```

```
        oct5_lum=3,
```

```
size[2]={SA_WIDTH>>1+oct5_lum.SA_HEIGHT>>1+oct5_lum};
```

```
for(channel=0;channel<3;channel++) {
```

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```

    int
frame_size[2] = {SA_WIDTH > > (channel == 0 ? 0 : 1), SA_HEIGHT > > (channel == 0 ? 0 : 1
)}).

    frame_area = frame_size[0] * frame_size[1];

    for(i=0; i < frame_area; i++)
src[channel][i] = src[channel][i] << SA_PRECISION;
    Convolve(src[channel], False, frame_size, 0, channel == 0 ? 3 : 2);
}
bwrite((char *)&quant_const, sizeof(double)*8, bfp);
SendLPF_SA(mode, src, dst, bfp, quant_const);
for(y=0; y < size[1]; y++) for(x=0; x < size[0]; x++) {
    int    empty = EMPTY, full = FULL;

    for(channel=0; channel < 3; channel++) {
        int    octs = channel != 0 ? 2 : 3;

        for(sub=1; sub < 4; sub++)
(void)SendTreeSA(mode, x, y, octs-1, sub, channel, src, dst, &empty, 0, quant_const, bfp);
        switch(empty) {
            case FULL:
                empty = CHANNEL_EMPTY;
                break;
            case CHANNEL_EMPTY:
SendTokenSA(CHANNEL_ZERO, channel, sub, octs-1, bfp, &full, 0);
                break;
        }
    }
}
if (empty == EMPTY)
SendTokenSA(LOCAL_ZERO, channel, sub, octs_lum-1, bfp, &full, 0);
}
}

```

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source/KlicsTestSA.c

```

#include    "xwave.h"
#include    "KlicsSA.h"

extern void  CompressFrameSA();

typedef     struct {
    Video src;
    char  bin_name[STRLEN];
    Boolean  stillvid;
    double  quant_const;
} KlicsCtrlRec, *KlicsCtrl;

/*  Function Name:    KlicsCtrlSA
 *  Description:    Test harness for KlicsSA in xwave
 *  Arguments:      w - Xaw widget
 *                  closure - compression control record
 *                  call_data - NULL
 *  Returns:        send data to binary file
 */

void  KlicsCtrlSA(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    KlicsCtrl  curl=(KlicsCtrl)closure;
    int  sizeY=SA_WIDTH*SA_HEIGHT,

```

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sizeUV = SA\_WIDTH\*SA\_HEIGHT/4. i. z;

```
short *dst[3]={
    (short *)MALLOC(sizeof(short)*sizeY),
    (short *)MALLOC(sizeof(short)*sizeUV),
    (short *)MALLOC(sizeof(short)*sizeUV),
}, *src[3]={
    (short *)MALLOC(sizeof(short)*sizeY),
    (short *)MALLOC(sizeof(short)*sizeUV),
    (short *)MALLOC(sizeof(short)*sizeUV),
};
```

char file\_name[STRLEN];

Bits bfp;

Boolean true=True, false=False;

```
for(i=0;i<sizeY;i++) dst[0][i]=0;
```

```
for(i=0;i<sizeUV;i++) { dst[1][i]=0; dst[2][i]=0; }
```

```
sprintf(file_name,"%s%s/%s%s\0",global->home,KLICSA_DIR,ctrl->bin_name,KLICSA_SA_EXT);
```

```
bfp=bopen(file_name,"w");
```

```
bwrite(&ctrl->stillvid,1,bfp);
```

```
bwrite(&ctrl->src->size[2],sizeof(int)*8,bfp);
```

```
for(z=0;z<ctrl->src->size[2];z++) {
```

```
    GetFrame(ctrl->src,z);
```

```
    for(i=0;i<sizeY;i++) src[0][i]=ctrl->src->data[0][z][i];
```

```
    for(i=0;i<sizeUV;i++) {
```

```
        src[1][i]=ctrl->src->data[1][z][i];
```

```
        src[2][i]=ctrl->src->data[2][z][i];
```

```
    }
```

```
    CompressFrameSA(z==0 ||
```

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```
ctrl->stillvid?STILL:SEND.src.dst.bfp,ctrl->quant_const);
```

```
    FreeFrame(ctrl->src.z);
```

```
    }
```

```
    bflush(bfp);
```

```
    bclose(bfp);
```

```
    XtFree(dst[0]);
```

```
    XtFree(dst[1]);
```

```
    XtFree(dst[2]);
```

```
    XtFree(src[0]);
```

```
    XtFree(src[1]);
```

```
    XtFree(src[2]);
```

```
}
```

```
KlicsCtrl    InitKlicsCtrl(name)
```

```
String name;
```

```
{
```

```
    KlicsCtrl    ctrl=(KlicsCtrl)MALLOC(sizeof(KlicsCtrlRec));
```

```
    ctrl->stillvid=True;
```

```
    ctrl->quant_const=8.0;
```

```
    strcpy(ctrl->bin_name.name);
```

```
    return(ctrl);
```

```
}
```

```
#define    KLICS_SA_ICONS    8
```

```
#define KLICS_SA_VID_ICONS    2
```

```
void    KlicsSA(w,closure.call_data)
```

```
Widget    w;
```



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```

caddr_t      closure. call_data;

{
    Video video=(Video)closure;
    KlicsCurl   ctrl=InitKlicsCurl(video->name);
    FloatInput flt_inputs=(FloatInput)MALLOC(sizeof(FloatInputRec));
    Message     msg_bin=NewMessage(ctrl->bin_name.NAME_LEN);
    XtCallbackRec  destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)flt_inputs},
        {CloseMessage,(caddr_t)msg_bin},
        {NULL,NULL},
    };
    Widget      parent=FindWidget("frm_compress".XtParent(w)),

    shell=ShellWidget("klicsSA",parent,SW_below,NULL,destroy_call),
        form=FormWidget("klicsSA_form",shell),
        widgets[KLICS_SA_ICONS],
    vid_widgets[KLICS_SA_VTD_ICONS];
    FormItem     items[]={
        {"klicsSA_cancel","cancel",0,0,FW_icon,NULL},
        {"klicsSA_confirm","confirm",1,0,FW_icon,NULL},
        {"klicsSA_title","Run Klics SA",2,0,FW_label,NULL},
        {"klicsSA_bin_lab","KLICS File:",0,3,FW_label,NULL},
        {"klicsSA_bin_name".NULL,4,3,FW_text,(String)msg_bin},

        {"klicsSA_qn_float".NULL,0,5,FW_float,(String)&flt_inputs[0]},
        {"klicsSA_qn_scroll".NULL,6,5,FW_scroll,(String)&flt_inputs[0]},
        {"klicsSA_vid_form".NULL,0,7,FW_form,NULL},
    }, vid_items[]={
        {"klicsSA_ic_lab","Image Comp:",0,0,FW_label,NULL},
        {"klicsSA_ic".NULL,1,0,FW_yn,(String)&ctrl->stillvid},
    };
};

```

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```

XtCallbackRec    callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {KlicsCurlSA,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {FloatDocDec,(caddr_t)&flt_inputs[0]}, {NULL,NULL},
}, vid_call[]={
    {ChangeYN,(caddr_t)&ctrl->stillvid}, {NULL,NULL},
};

```

```

ctrl->src=video;
msg_bin->rows=1; msg_bin->cols=NAME_LEN;

```

```

flt_inputs[0].format="Quant: %4.1f";
flt_inputs[0].max=10;
flt_inputs[0].min=0;
flt_inputs[0].value= &ctrl->quant_const;

```

```

FillForm(form,KLICS_SA_ICONS-(video->size[2]>1?0:1),items.widgets.callbacks);

```

```

if (video->size[2]>1)

```

```

FillForm(widgets[7],KLICS_SA_VID_ICONS,vid_items.vid_widgets.vid_call);

```

```

XtPopup(shell,XtGrabExclusive);

```

```

}

```

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source/Malloc.c

```
/*  
    Memory allocation routine  
*/  
  
#include    <stdio.h>  
  
char  *MALLOC(size)  
  
int    size;  
  
{  
    char *ptr=(char *)calloc(1,size);  
  
    if (ptr == NULL) Eprintf("Unable to allocate %d bytes of memory\n",size);  
    return(ptr);  
}
```

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## source/Menu.c

/\*

\* Pull-Right Menu functions

\*/

#include &lt;stdio.h&gt;

#include &lt;X11/IntrinsicP.h&gt;

#include &lt;X11/StringDefs.h&gt;

#include &lt;X11/Xaw/XawInit.h&gt;

#include &lt;X11/Xaw/SimpleMenP.h&gt;

#include &lt;X11/Xaw/CommandP.h&gt;

static void prPopupMenu();

static void NotifyImage();

static void PrLeave();

void InitActions(app\_con)

XtAppContext app\_con;

{

```
static XtActionsRec actions[]={
    {"prPopupMenu",prPopupMenu},
    {"notifyImage",NotifyImage},
    {"prLeave",PrLeave}.

```

};

XtAppAddActions(app\_con.actions,XtNumber(actions));

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}

```
static void prPopupMenu(w.event.params.num_params)
```

```
Widget w;
```

```
XEvent * event;
```

```
String * params;
```

```
Cardinal * num_params;
```

{

```
Widget menu, temp;
```

```
Arg arglist[2];
```

```
Cardinal num_args;
```

```
int menu_x, menu_y, menu_width, menu_height, button_width, button_height;
```

```
Position button_x, button_y;
```

```
if (*num_params != 1) {
```

```
    char error_buf[BUFSIZ];
```

```
    sprintf(error_buf, "prPopupMenu: %s.", "Illegal number of translation  
arguments");
```

```
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
```

```
    return;
```

}

```
temp = w;
```

```
while(temp != NULL) {
```

```
    menu = XtNameToWidget(temp, params[0]);
```

```
    if (menu == NULL)
```

```
        temp = XtParent(temp);
```

```
    else
```

```
        break;
```

}

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```
if (menu == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "prPopupMenu: %s %s.",
            "Could not find menu widget named", params(0));
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}
if (!XtIsRealized(menu))
    XtRealizeWidget(menu);

menu_width = menu->core.width + 2 * menu->core.border_width;
button_width = w->core.width + 2 * w->core.border_width;
button_height = w->core.height + 2 * w->core.border_width;

menu_height = menu->core.height + 2 * menu->core.border_width;

XtTranslateCoords(w, 0, 0, &button_x, &button_y);
menu_x = button_x;
menu_y = button_y + button_height;

if (menu_x < 0)
    menu_x = 0;
else {
    int scr_width = WidthOfScreen(XtScreen(menu));
    if (menu_x + menu_width > scr_width)
        menu_x = scr_width - menu_width;
}

if (menu_y < 0)
    menu_y = 0;
else {
    int scr_height = HeightOfScreen(XtScreen(menu));
```

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```

    if (menu_y + menu_height > scr_height)
        menu_y = scr_height - menu_height;
}

```

```

num_args = 0;

```

```

XtSetArg(arglist[num_args], XtNx, menu_x); num_args++;

```

```

XtSetArg(arglist[num_args], XtNy, menu_y); num_args++;

```

```

XtSetValues(menu, arglist, num_args);

```

```

XtPopupSpringLoaded(menu);

```

```

}

```

```

/*

```

```

static void

```

```

prRealize(w, mask, attrs)

```

```

Widget w;

```

```

Mask *mask;

```

```

XSetWindowAttributes *attrs;

```

```

{

```

```

    (*superclass->core_class.realize) (w, mask, attrs);

```

```

*/

```

```

/* We have a window now. Register a grab. */

```

```

/*

```

```

XGrabButton( XtDisplay(w), AnyButton, AnyModifier, XtWindow(w),

```

```

    TRUE, ButtonPressMask|ButtonReleaseMask,

```

```

    GrabModeAsync, GrabModeAsync, None, None );

```

```

}

```

```

*/

```

```

static void NotifyImage(w,event,params,num_params)

```

```

Widget      w;

```

```

XEvent      *event;

```

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`String *params;``Cardinal *num_params;``{` `CommandWidget cbw=(CommandWidget)w;` `if (cbw->command.set) XtCallCallbackList(w,cbw->command.callbacks,event);``}``static void PrLeave(w,event.params.num_params)``Widget w;``XEvent *event;``String *params;``Cardinal *num_params;``{` `SimpleMenuWidget smw=(SimpleMenuWidget)w;` `Dprintf("PrLeave\n");``}`



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## source/Message.c

```
/*
 *   Message I/O Utility Routines
 */

#include    "../include/xwave.h"
#include    < varargs.h >

#define     MESS_ICONS      3

void  TextSize(msg)

Message    msg;

{
    int     i=-1, max_len=0;
    char    *text=msg->info.ptr;

    msg->rows=0;
    msg->cols=0;
    do {
        i++;
        if (text[i]=='\n' || text[i]=='\0') {
            if (msg->cols > max_len) max_len=msg->cols;
            msg->cols=0;
            msg->rows++;
        } else msg->cols++;
    } while (text[i]!='\0');
    if (i>0) if (text[i-1]=='\n') msg->rows--;
```

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```

    msg->cols = max_len;
}

Message    NewMessage(text.size)

char    *text;
int     size;

{
    Message    msg = (Message)MALLOC(sizeof(MessageRec));

    msg->shell = NULL;
    msg->widget = NULL;
    msg->info.firstPos = 0;
    if (! (msg->own_text = text == NULL)) msg->info.ptr = text;
    else {
        msg->info.ptr = (char *)MALLOC(size + 1);
        msg->info.ptr[0] = '\0';
    }
    msg->info.format = FMT8BIT;
    msg->info.length = 0;
    msg->rows = 0;
    msg->cols = 0;
    msg->size = size;
    msg->edit = XawtextEdit;
    return(msg);
}

void    CloseMessage(w,closure,call_data)

```

```

Widget    w;
.caddr_t    closure, call_data;

```

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```

{
    Message      msg = (Message)closure;

    Destroy(w,(caddr_t)msg->shell.NULL);
    if (msg->own_text) XtFree(msg->info.ptr);
    XtFree(msg);
}

void  MessageWindow(parent.msg,title.close.call)

Widget      parent;
Message      msg;
char  *title;
Boolean      close;
XtCallbackRec  call[];

{
    Widget      form, widgets[MESS_ICONS]={NULL,NULL,NULL};
    FormItem      items[]={
        {"msg_cancel","cancel",0,0,FW_icon.NULL},
        {"msg_label",title,1,0,FW_label.NULL},
        {"msg_msg",NULL,0,2,FW_text.(String)msg},
    };

    msg->edit = XawTextRead;

    msg->shell = ShellWidget("msg",parent,parent == global->toplevel?SW_top:SW_below,
    NULL.NULL);

    form = FormWidget("msg_form",msg->shell);

    FillForm(form,MESS_ICONS-(close?0:1),&items[close?0:1],&widgets[close?0:1],call);
    XtPopup(msg->shell,XtGrabNone);
}

```

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```

    Mflush(msg);
}

void Mflush(msg)

Message    msg;

{
    if (global->batch == NULL && msg->widget != NULL) {
        Display    *dpy = XtDisplay(global->toplevel);
        int    i, lines=0;
        Arg    args[1];

        for(i=msg->info.length-1; lines < msg->rows && i >= 0; i--)
            if (msg->info.ptr[i] == '\n' && i != msg->info.length-1) lines++;
        i++;
        if (msg->info.ptr[i] == '\n') i++;
        strcpy(msg->info.ptr, &msg->info.ptr[i]);
        msg->info.length = i;
        XtSetArg(args[0], XtNstring, msg->info.ptr);
        XSynchronize(dpy, True);
        XtSetValues(msg->widget, args, ONE);
        XSynchronize(dpy, False);
    }
}

void mprintf(msg, ap)

Message    msg;
va_list    ap;

{

```

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```
char *format;
```

```
format = va_arg(ap, char *);
```

```
if (global->batch != NULL) vprintf(format, ap);
```

```
else {
```

```
    char text[STRLEN];
```

```
    int i;
```

```
    vsprintf(text, format, ap);
```

```
    i = strlen(text) + msg->info.length - msg->size;
```

```
    if (i > 0) {
```

```
        strcpy(msg->info.pur, &msg->info.pur[i]);
```

```
        msg->info.length -= i;
```

```
    }
```

```
    strcat(msg->info.pur, text);
```

```
    msg->info.length += strlen(text);
```

```
}
```

```
}
```

```
void Dprintf(va_list)
```

```
va_dcl
```

```
{
```

```
    va_list ap;
```

```
    if (global->debug) {
```

```
        char *format;
```

```
        va_start(ap);
```

```
        format = va_arg(ap, char *);
```

```
        vprintf(format, ap);
```

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```

        va_end(ap);
    }
}

void  Mprintf(va_alist)

va_dcl

{
    va_list      ap;
    Message      msg;

    va_start(ap);
    msg = va_arg(ap, Message);
    mprintf(msg, ap);
    va_end(ap);
}

void  Eprintf(va_alist)

va_dcl

{
    va_list      ap;
    Message      msg;
    int          rows, cols;

    va_start(ap);
    msg = NewMessage(NULL, STRLEN);
    mprintf(msg, ap);
    if (global->batch == NULL) {
        XtCallbackRec      callbacks[] = {

```

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```
    {CloseMessage,(caddr_t)msg},  
    {NULL,NULL},  
};
```

```
    TextSize(msg);
```

```
    MessageWindow(global->toplevel,msg,"Xwave Error".True.callbacks);
```

```
}
```

```
va_end(ap);
```

```
}
```

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source/NameButton.c

```
/*
 * Supply MenuButton widget id to PullRightMenu button resource
 */

#include    "../include/xwave.h"

void NameButton(w, event, params, num_params)

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

{
    MenuButtonWidget mbw=(MenuButtonWidget) w;
    Widget menu;
    Arg args[1];
    String name;
    XtSetArg(args[0],XtNmenuName,&name);
    XtGetValues(w,args,ONE);
    Dprintf("NameButton: looking for PRM %s\n",name);
    menu=FindWidget(name,w);
    if (menu != NULL) {
        Dprintf("NameButton: setting Menu Button\n");
        XtSetArg(args[0],XtNbutton,w);
        XtSetValues(menu,args,ONE);
    }
}
```



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## source/Palette.c

```

/*
 *   Palette re-mapping
 */

#include    "../include/xwave.h"

/*
 *   Function Name:      ReMap
 *   Description:      Re-maps a pixel value to a new value via a mapping
 *   Arguments:      pixel - pixel value (0..max-1)
 *                   max - range of pixel values
 *                   map - palette to recode with
 *   Returns:      remapped pixel value
 */

int  ReMap(pixel,max,palette)

int  pixel, max;
Palette  palette;

{
    Map  map = palette->mappings;
    int  value = pixel;
    Boolean  inrange = False;

    while(map != NULL && !inrange) {
        if (pixel >= map->start && pixel <= map->finish) {
            inrange = True;
            value = map->m*pixel + map->c;

```

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```

    }
    map = map->next;
}
return(value < 0?0:value > = max?max-1:value);
}

```

```

/*  Function Name:      FindPalette
 *  Description:  Find a palette from a list given the index
 *  Arguments:   palette - the palette list
 *               index - the index number
 *  Returns:     the palette corresponding to the index
 */

```

```

Palette      FindPalette(palette,index)

```

```

Palette      palette;
int          index;

{
    while(index > 0 && palette->next != NULL) {
        index--;
        palette = palette->next;
    }
    return(palette);
}

```

```

/*  Function Name:      ReOrderPalettes
 *  Description:  Reverse the order of the palette list
 *  Arguments:   start, finish - the start and finish of the re-ordered list
 *  Returns:     the palette list in the reverse order
 */

```

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Palette ReOrderPalettes(start, finish)

Palette start, finish:

```
{  
    Palette list = finish->next;  
  
    if (list != NULL) {  
        finish->next = list->next;  
        list->next = start;  
        start = ReOrderPalettes(list, finish);  
    }  
    return(start);  
}
```

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## source/Parse.c

```
/*
 *   Parser for xwave input files: .elo
 */

#include    "../include/xwave.h"
#include    "../include/Gram.h"

void  Parse(path,file,ext)

String path, file, ext;

{
    char  file_name[STRLEN];

    sprintf(file_name,"%s%s/%s%s\0",global->home,path,file,ext);
    Dprintf("Parse: parsing file %s\n",file_name);
    if (NULL == (global->parse_fp=fopen(file_name,"r")))
        Eprintf("Parse: failed to open input file %s\n",file_name);
    else {
        sprintf(file_name,"%s%s\0",file,ext);
        global->parse_file=file_name;
        global->parse_token=ext;
        yyparse();
        fclose(global->parse_fp);
        Dprintf("Parse: finished with %s\n",file_name);
    }
}
```

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```
void ParseCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data:
```

```
{
    Parse(".",((XawListReturnStruct *)call_data)->string,(String)closure);
}
```

```
int ParseInput(fp)
```

```
FILE *fp;
```

```
{
    int num;

    if (global->parse_token != NULL)
        if (global->parse_token[0] == '\0') {
            num = (int)'\n';
            global->parse_token = NULL;
        } else {
            num = (int)global->parse_token[0];
            global->parse_token++;
        }
    else if (EOF == (num =getc(global->parse_fp))) num = NULL;
    return(num);
}
```

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source/Pop2.c

/\*

Global callbacks for popping popups and assorted utilities

\*/

#include "../include/xwave.h"

void Destroy(w,closure,call\_data)

Widget w;

caddr\_t closure, call\_data;

{

Widget widget=(Widget)closure;

if (widget!=NULL) XtDestroyWidget(widget);

}

void Quit(w,closure,call\_data)

Widget w;

caddr\_t closure, call\_data;

{

XtDestroyApplicationContext(global-&gt;app\_con);

exit();

}

void Free(w,closure,call\_data)

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```
Widget      w;
caddr_t     closure, call_data;
```

```
{
    if (closure != NULL) XFree(closure);
}
```

```
Widget      FindWidget(name, current)
```

```
String name;
```

```
Widget      current;
```

```
{
    Widget      target = NULL;

    while(current != NULL) {
        target = XtNameToWidget(current, name);
        if (target == NULL) current = XtParent(current);
        else break;
    }
    if (target == NULL) {
        Eprintf("Can't find widget: %s\n", name);
        target = global->toplevel;
    }
    return(target);
}
```

```
#define      NA_ICONS 2
```

```
void  NA(w, closure, call_data)
```

```
Widget      w;
```

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```

caddr_t      closure, call_data;

{
    Widget
    shell = ShellWidget("na_shell", (Widget)closure, SW_below, NULL, NULL),
        form = FormatWidget("na_form", shell), widgets[NA_ICONS];
    FormItem  items[] = {
        {"na_confirm", "confirm", 0, 0, FW_icon, NULL},
        {"na_label", "This function is not available", 0, 1, FW_label, NULL},
    };
    XtCallbackRec  callbacks[] = {
        {Destroy, (caddr_t)shell}, {NULL, NULL},
    };

    FillForm(form, NA_ICONS, items, widgets, callbacks);
    XtPopup(shell, XtGrabExclusive);
}

void  SetSensitive(w, closure, call_data)

Widget      w;
caddr_t      closure, call_data;

{
    XtSetSensitive((Widget)closure, True);
}

```



## source/Process.c

```
/*
 *   Call sub-processes
 */

#include    "../include/xwave.h"
#include    <signal.h>
#include    <sys/wait.h>
#include    <sys/time.h>
#include    <sys/resource.h>

/*
 *   Function Name:    Fork
 *   Description:    Executes a file in a process and waits for termination
 *   Arguments:        argv - standard argv argument description
 *   Returns:          dead process id
 */

int    Fork(argv)

char    *argv[];

{
    int    pid;
    union wait    statusp;
    struct rusage    rusage;

    if (0 == (pid = fork())) {
        execvp(argv[0], argv);
        exit();
    }
}
```

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```

    } else if (pid > 0) wait4(pid,&statusp,0,&rusage);
    return(pid);
}

/*  Funcuon Name:      zropen
 *   Description:      Open a file (or .Z file) for reading
 *   Arguments:        file_name - name of the file to be read
 *                      pid - pointer to process id
 *   Returns:          file pointer
 */

```

```
FILE *zropen(file_name,pid)
```

```
char *file_name;
```

```
int *pid;
```

```

{
    char z_name[STRLEN];
    String zcat[] = {"zcat",z_name,NULL};
    FILE *fp;

    if (NULL == (fp = fopen(file_name,"r"))) {
        static int up[2];

        sprintf(z_name,"%s.Z",file_name);
        pipe(up);
        if (0 != (*pid = fork())) {
            Dprintf("Parent process started\n");
            close(up[1]);
            fp = fdopen(up[0],"r");
        } else {
            Dprintf("Running zcat on %s\n",zcat[1]);

```

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```

        close(up[0]);
        dup2( up[1], 1 );
        close( up[1] );
        execvp(zcat[0],zcat);
    }
}
return(fp);
}

```

```

/*  Function Name:      zseek
 *  Description:  Fast-forward thru file (fseek will not work on pipes)
 *  Arguments:   fp - file pointer
 *               bytes - bytes to skip
 */

```

```
void  zseek(fp,bytes)
```

```
FILE *fp;
```

```
int  bytes;
```

```

{
    char  scratch[1000];
    int  i;

    while(bytes > 0) {
        int  amount = bytes > 1000?1000:bytes;

        fread(scratch,sizeof(char),amount,fp);
        bytes -= amount;
    }
}

```

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```
void zclose(fp.pid)
```

```
FILE *fp;
```

```
int pid;
```

```
{
```

```
    union wait statusp;
```

```
    struct rusage rusage;
```

```
    fclose(fp);
```

```
    if (pid != 0) wait4(pid, &statusp, 0, &rusage);
```

```
}
```

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source/PullRightMenu.c

#if ( !defined(lint) &amp;&amp; !defined(SABER) )

static char Xrcsid[] = "\$XConsortium: PullRightMenu.c.v 1.32 89/12/11 15:01:50 kit  
Exp \$";

#endif

/\*

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• CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

\*/

/\*

• PullRightMenu.c - Source code file for PullRightMenu widget.

•

\*/

#include <stdio.h>

#include <X11/IntrinsicP.h>

#include <X11/StringDefs.h>

#include <X11/Xaw/XawInit.h>

#include <X11/Xaw/SimpleMenP.h>

#include "PullRightMenuP.h"

#include <X11/Xaw/SmeBSB.h>

#include "SmeBSBpr.h"

#include <X11/Xaw/Cardinals.h>

#include <X11/Xmu/Initer.h>

#include <X11/Xmu/CharSet.h>

#define streq(a, b) ( strcmp((a), (b)) == 0 )

#define offset(field) XtOffset(PullRightMenuWidget, simple\_menu.field)

static XtResource resources[] = {

/\*

• Label Resources.

\*/

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```
{XtNlabel, XtCLabel, XtRString, sizeof(String),
  offset(label_string), XtRString, NULL},
```

```
{XtNlabelClass, XtCLabelClass, XtRPointer, sizeof(WidgetClass),
  offset(label_class), XtRImmediate, (caddr_t) NULL},
```

/\*

```
• Layout Resources.
```

\*/

```
{XtNrowHeight, XtCRowHeight, XtRDimension, sizeof(Dimension),
  offset(row_height), XtRImmediate, (caddr_t) 0},
```

```
{XtNtopMargin, XtCVerticalMargins, XtRDimension, sizeof(Dimension),
  offset(top_margin), XtRImmediate, (caddr_t) 0},
```

```
{XtNbottomMargin, XtCVerticalMargins, XtRDimension, sizeof(Dimension),
  offset(bottom_margin), XtRImmediate, (caddr_t) 0},
```

/\*

```
• Misc. Resources
```

\*/

```
{ XtNallowShellResize, XtCAllowShellResize, XtRBoolean, sizeof(Boolean),
  XtOffset(SimpleMenuWidget, shell.allow_shell_resize),
  XtRImmediate, (XtPointer) TRUE },
```

```
{XtNcursor, XtCCursor, XtRCursor, sizeof(Cursor),
  offset(cursor), XtRImmediate, (caddr_t) None},
```

```
{XtNmenuOnScreen, XtCMenuOnScreen, XtRBoolean, sizeof(Boolean),
  offset(menu_on_screen), XtRImmediate, (caddr_t) TRUE},
```

```
{XtNpopupOnEntry, XtCPopupOnEntry, XtRWidget, sizeof(Widget),
  offset(popup_entry), XtRWidget, NULL},
```

```
{XtNbackingStore, XtCBackingStore, XtRBackingStore, sizeof(int),
  offset(backing_store),
```

```
XtRImmediate, (caddr_t) (Always + WhenMapped + NotUseful)}.
```

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```
{XtNbutton, XtCWidget, XtRWidget, sizeof(Widget),
  offset(button), XtRWidget, (XtPointer)NULL},
```

```
};
```

```
#undef offset
```

```
static char defaultTranslations[] =
```

```
" <EnterWindow>:  highlight()      \n\
  <LeaveWindow>:    pull()           \n\
  <BtnMotion>:      highlight()      \n\
  <BtnUp>:          execute()";
```

```
/*
```

```
 * Semi Public function definitions.
```

```
*/
```

```
static void Redisplay(), Realize(), Resize(), ChangeManaged();
```

```
static void Initialize(), ClassInitialize(), ClassPartInitialize();
```

```
static Boolean SetValues(), SetValuesHook();
```

```
static XtGeometryResult GeometryManager();
```

```
/*
```

```
 * Action Routine Definitions
```

```
*/
```

```
static void Highlight(), Unhighlight(), Pull(), Execute(), Notify(), PositionMenuAction();
```

```
/*
```

```
 * Private Function Definitions.
```

```
*/
```

```
static void MakeSetValuesRequest(), CreateLabel(), Layout();
```

```
static void AddPositionAction(), PositionMenu(), ChangeCursorOnGrab();
```



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```
static Dimension GetMenuWidth(), GetMenuHeight();
```

```
static Widget FindMenu();
```

```
static SmeObject GetEventEntry();
```

```
static XtActionsRec actionsList[] =
```

```
{
    {"pull",          Pull},
    {"execute",       Execute},
    {"notify",        Notify},
    {"highlight",     Highlight},
    {"unhighlight",   Unhighlight},
};
```

```
CompositeClassExtensionRec pr_extension_rec = {
```

```
    /* next_extension */ NULL,
    /* record_type */     NULLQUARK,
    /* version */         XtCompositeExtensionVersion,
    /* record_size */     sizeof(CompositeClassExtensionRec),
    /* accepts_objects */ TRUE,
};
```

```
#define superclass (&overrideShellClassRec)
```

```
PullRightMenuClassRec pullRightMenuClassRec = {
```

```
{
    /* superclass */ (WidgetClass) superclass,
    /* class_name */  "PullRightMenu",
    /* size */        sizeof(PullRightMenuRec),
    /* class_initialize */ ClassInitialize,
    /* class_part_initialize */ ClassPartInitialize,
    /* Class init'ed */  FALSE,
    /* initialize */    Initialize.
};
```

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```

/* initialize_book */ NULL.
/* realize */ Realize.
/* actions */ actionsList.
/* num_actions */ XtNumber(actionsList).
/* resources */ resources.
/* resource_count */ XtNumber(resources).
/* xrm_class */ NULLQUARK.
/* compress_motion */ TRUE.
/* compress_exposure */ TRUE.
/* compress_enterleave*/ TRUE.
/* visible_interest */ FALSE.
/* destroy */ NULL.
/* resize */ Resize.
/* expose */ Redisplay.
/* set_values */ SetValues.
/* set_values_hook */ SetValuesHook.
/* set_values_almost */ XtInheritSetValuesAlmost.
/* get_values_hook */ NULL.
/* accept_focus */ NULL.
/* intrinsics version */ XtVersion.
/* callback offsets */ NULL.
/* tm_table */ defaultTranslations.
/* query_geometry */ NULL.
/* display_accelerator*/ NULL.
/* extension */ NULL
},{
/* geometry_manager */ GeometryManager.
/* change_managed */ ChangeManaged.
/* insert_child */ XtInheritInsertChild.
/* delete_child */ XtInheritDeleteChild.
/* extension */ NULL
},{

```

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```

/* Shell extension      */ NULL
}{
/* Override extension */ NULL
}{
/* Simple Menu extension*/ NULL
}
};

```

```
WidgetClass pullRightMenuWidgetClass = (WidgetClass)&pullRightMenuClassRec;
```

```

.....
*
* Semi-Public Functions.
*
...../

```

```

/*   Function Name: ClassInitialize
*   Description: Class Initialize routine, called only once.
*   Arguments: none.
*   Returns: none.
*/

```

```
static void
```

```
ClassInitialize()
```

```

{
  XawInitializeWidgetSet();
  XtAddConverter( XtRString, XtRBackingStore, XmuCvtStringToBackingStore,
                  NULL, 0 );
  XmuAddInitializer( AddPositionAction, NULL);
}

```

```
/*   Function Name: ClassInitialize
```

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- Description: Class Part Initialize routine. called for every
- subclass. Makes sure that the subclasses pick up
- the extension record.
- Arguments: wc - the widget class of the subclass.
- Returns: none.
- /

static void

ClassPartInitialize(wc)

WidgetClass wc;

{

SimpleMenuWidgetClass smwc = (SimpleMenuWidgetClass) wc;

/\*

- Make sure that our subclass gets the extension rec too.
- /

pr\_extension\_rec.next\_extension = smwc-&gt;composite\_class.extension;

smwc-&gt;composite\_class.extension = (caddr\_t) &amp;pr\_extension\_rec;

}

/\* Function Name: Initialize

- Description: Initializes the simple menu widget
- Arguments: request - the widget requested by the argument list.
- new - the new widget with both resource and non
- resource values.
- Returns: none.
- /

/\* ARGSUSED \*/

static void

Initialize(request, new)

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```

Widget request. new;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) new;

    XmuCallInitializers(XtWidgetToApplicationContext(new));

    if (smw->simple_menu.label_class == NULL)
        smw->simple_menu.label_class = smeBSBObjectClass;

    smw->simple_menu.label = NULL;
    smw->simple_menu.entry_set = NULL;
    smw->simple_menu.recursive_set_values = FALSE;

    if (smw->simple_menu.label_string != NULL)
        CreateLabel(new);

    smw->simple_menu.menu_width = TRUE;

    if (smw->core.width == 0) {
        smw->simple_menu.menu_width = FALSE;
        smw->core.width = GetMenuWidth(new, NULL);
    }

    smw->simple_menu.menu_height = TRUE;

    if (smw->core.height == 0) {
        smw->simple_menu.menu_height = FALSE;
        smw->core.height = GetMenuHeight(new);
    }
}

```

/\*

- Add a popup\_callback routine for changing the cursor.

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\*/

```

XtAddCallback(new, XtNpopupCallback, ChangeCursorOnGrab, NULL);
}

```

```

/* Function Name: Redisplay

```

- Description: Redisplays the contents of the widget.
- Arguments: w - the simple menu widget.
- event - the X event that caused this redisplay.
- region - the region the needs to be repainted.
- Returns: none.

\*/

```

/* ARGSUSED */

```

```

static void

```

```

Redisplay(w, event, region)

```

```

Widget w;

```

```

XEvent * event;

```

```

Region region;

```

```

{

```

```

    SimpleMenuWidget smw = (SimpleMenuWidget) w;

```

```

    SmeObject * entry;

```

```

    SmeObjectClass class;

```

```

    if (region == NULL)

```

```

        XClearWindow(XtDisplay(w), XtWindow(w));

```

```

/*

```

- Check and Paint each of the entries - including the label.

\*/

```

ForAllChildren(smw, entry) {

```

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```
if (!XtIsManaged ( (Widget) *entry)) continue;
```

```
if (region != NULL)
```

```
    switch(XRectInRegion(region, (int) (*entry)->rectangle.x,
```

```
            (int) (*entry)->rectangle.y,
```

```
            (unsigned int) (*entry)->rectangle.width,
```

```
            (unsigned int) (*entry)->rectangle.height)) {
```

```
    case RectangleIn:
```

```
    case RectanglePart:
```

```
        break;
```

```
    default:
```

```
        continue;
```

```
    }
```

```
class = (SmeObjectClass) (*entry)->object.widget_class;
```

```
if (class->rect_class.expose != NULL)
```

```
    (class->rect_class.expose)( (Widget) *entry, NULL, NULL);
```

```
}
```

```
}
```

```
/*  Function Name: Realize
```

```
•  Description: Realizes the widget.
```

```
•  Arguments: w - the simple menu widget.
```

```
•           mask - value mask for the window to create.
```

```
•           attrs - attributes for the window to create.
```

```
•  Returns: none
```

```
*/
```

```
static void
```

```
Realize(w, mask, attrs)
```

```
Widget w:
```

```
XtValueMask * mask:
```

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```

XSetWindowAttributes * attrs;

{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;

    attrs->cursor = smw->simple_menu.cursor;
    *mask |= CWCursor;
    if ((smw->simple_menu.backing_store == Always) ||
        (smw->simple_menu.backing_store == NotUseful) ||
        (smw->simple_menu.backing_store == WhenMapped) ) {
        *mask |= CWBackingStore;
        attrs->backing_store = smw->simple_menu.backing_store;
    }
    else
        *mask &= ~CWBackingStore;

    (*superclass->core_class.realize) (w, mask, attrs);
}

```

```

/*  Function Name: Resize
    *  Description: Handle the menu being resized bigger.
    *  Arguments: w - the simple menu widget.
    *  Returns: none.
    */

```

```

static void
Resize(w)
Widget w;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;

    if ( !XIsRealized(w) ) return;

```



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```
ForAllChildren(smw, entry) /* reset width of all entries. */
```

```
if (XtIsManaged( (Widget) *entry))
```

```
    (*entry)->rectangle.width = smw->core.width;
```

```
Redisplay(w, (XEvent *) NULL, (Region) NULL);
```

```
}
```

```
/* Function Name: SetValues
```

```
• Description: Relayout the menu when one of the resources is changed.
```

```
• Arguments: current - current state of the widget.
```

```
• request - what was requested.
```

```
• new - what the widget will become.
```

```
• Returns: none
```

```
*/
```

```
/* ARGSUSED */
```

```
static Boolean
```

```
SetValues(current, request, new)
```

```
Widget current, request, new;
```

```
{
```

```
    SimpleMenuWidget smw_old = (SimpleMenuWidget) current;
```

```
    SimpleMenuWidget smw_new = (SimpleMenuWidget) new;
```

```
    Boolean ret_val = FALSE, layout = FALSE;
```

```
    if (!XtIsRealized(current)) return(FALSE);
```

```
    if (!smw_new->simple_menu_recursive_set_values) {
```

```
        if (smw_new->core.width != smw_old->core.width) {
```

```
            smw_new->simple_menu_menu_width = (smw_new->core.width != 0);
```

```
            layout = TRUE;
```

```
        }
```

```
        if (smw_new->core.height != smw_old->core.height) {
```

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```

    smw_new->simple_menu.menu_height = (smw_new->core.height != 0);
    layout = TRUE;
}
}

if (smw_old->simple_menu.cursor != smw_new->simple_menu.cursor)
    XDefineCursor(XtDisplay(new),
        XtWindow(new), smw_new->simple_menu.cursor);

if (smw_old->simple_menu.label_string != smw_new->simple_menu.label_string)
    if (smw_new->simple_menu.label_string == NULL)        /* Destroy. */
        XtDestroyWidget(smw_old->simple_menu.label);
    else if (smw_old->simple_menu.label_string == NULL)    /* Create. */
        CreateLabel(new);
    else {                                                /* Change. */
        Arg args[1];

        XtSetArg(args[0], XtNlabel, smw_new->simple_menu.label_string);
        XtSetValues(smw_new->simple_menu.label, args, ONE);
    }

if (smw_old->simple_menu.label_class != smw_new->simple_menu.label_class)
    XtAppWarning(XtWidgetToApplicationContext(new),
        "No Dynamic class change of the SimpleMenu Label.");

if ((smw_old->simple_menu.top_margin != smw_new->simple_menu.top_margin)
||
    (smw_old->simple_menu.bottom_margin !=
    smw_new->simple_menu.bottom_margin) /* filler..... */ ) {
    layout = TRUE;
    ret_val = TRUE;
}

```

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if (layout)

Layout(new, NULL, NULL);

return(ret\_val);

}

/\* Function Name: SetValuesHook

\* Description: To handle a special case, this is passed the  
\* actual arguments.

\* Arguments: w - the menu widget.

\* arglist - the argument list passed to XtSetValues.

\* num\_args - the number of args.

\* Returns: none

\*/

/\*

\* If the user actually passed a width and height to the widget

\* then this MUST be used, rather than our newly calculated width and

\* height.

\*/

static Boolean

SetValuesHook(w, arglist, num\_args)

Widget w;

ArgList arglist;

Cardinal \*num\_args;

{

register Cardinal i;

Dimension width, height;

width = w->core.width;

height = w->core.height;

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```

for ( i = 0 ; i < *num_args ; i++ ) {
    if ( strcmp(arglist[i].name, XtNwidth) )
        width = (Dimension) arglist[i].value;
    if ( strcmp(arglist[i].name, XtNheight) )
        height = (Dimension) arglist[i].value;
}

if ((width != w->core.width) || (height != w->core.height))
    MakeSetValuesRequest(w, width, height);
return(FALSE);
}

/.....
*
* Geometry Management routines.
*
...../

/*  Function Name: GeometryManager
*
*  Description: This is the SimpleMenu Widget's Geometry Manager.
*
*  Arguments: w - the Menu Entry making the request.
*
*             request - requested new geometry.
*
*             reply - the allowed geometry.
*
*  Returns: XtGeometry{Yes, No, Almost}.
*/

static XtGeometryResult
GeometryManager(w, request, reply)
Widget w;
XtWidgetGeometry * request, * reply;
{

```

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```
SimpleMenuWidget smw = (SimpleMenuWidget) XtParent(w);
```

```
SmeObject entry = (SmeObject) w;
```

```
XtGeometryMask mode = request->request_mode;
```

```
XtGeometryResult answer;
```

```
Dimension old_height, old_width;
```

```
if ( !(mode & CWWidth) && !(mode & CWHeight) )
```

```
    return(XtGeometryNo);
```

```
reply->width = request->width;
```

```
reply->height = request->height;
```

```
old_width = entry->rectangle.width;
```

```
old_height = entry->rectangle.height;
```

```
Layout(w, &(reply->width), &(reply->height) );
```

```
/*
```

- Since we are an override shell and have no parent there is no one to
- ask to see if this geom change is okay, so I am just going to assume
- we can do whatever we want. If you subclass be very careful with this
- assumption, it could bite you.

```
•
```

```
• Chris D. Peterson - Sept. 1989.
```

```
*/
```

```
if ( (reply->width == request->width) &&
```

```
    (reply->height == request->height) ) {
```

```
    if ( mode & XtCWQueryOnly ) { /* Actually perform the layout. */
```

```
        entry->rectangle.width = old_width;
```

```
        entry->rectangle.height = old_height;
```

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```

    }
    else {
        Layout(( Widget) smw, NULL, NULL);
    }
    answer = XtGeometryDone;
}
else {
    entry->rectangle.width = old_width;
    entry->rectangle.height = old_height;

    if ( ((reply->width == request->width) && !(mode & CWHeight)) ||
        ((reply->height == request->height) && !(mode & CWWidth)) ||
        ((reply->width == request->width) &&
         (reply->height == request->height)) )
        answer = XtGeometryNo;
    else {
        answer = XtGeometryAlmost;
        reply->request_mode = 0;
        if (reply->width != request->width)
            reply->request_mode |= CWWidth;
        if (reply->height != request->height)
            reply->request_mode |= CWHeight;
    }
}
return(answer);
}

```

/\* Function Name: ChangeManaged

• Description: called whenever a new child is managed.

• Arguments: w - the simple menu widget.

• Returns: none.

\*/

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```
static void
```

```
ChangeManaged(w)
```

```
Widget w;
```

```
{
```

```
    Layout(w, NULL, NULL);
```

```
}
```

```
/*-----
```

```
*
```

```
* Global Action Routines.
```

```
*
```

```
* These actions routines will be added to the application's
```

```
* global action list.
```

```
*
```

```
-----*/
```

```
/* Function Name: PositionMenuAction
```

```
* Description: Positions the simple menu widget.
```

```
* Arguments: w - a widget (no the simple menu widget.)
```

```
*          event - the event that caused this action.
```

```
*          params, num_params - parameters passed to the routine.
```

```
*          we expect the name of the menu here.
```

```
* Returns: none
```

```
*/
```

```
/* ARGSUSED */
```

```
static void
```

```
PositionMenuAction(w, event, params, num_params)
```

```
Widget w;
```

```
XEvent * event;
```

```
String * params;
```

```
Cardinal * num_params;
```

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```
{
Widget menu;
XPoint loc;

if (*num_params != 1) {
char error_buf[BUFSIZ];
sprintf(error_buf, "%s %s",
        "Xaw - SimpleMenuWidget: position menu action expects only one",
        "parameter which is the name of the menu.");
XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
return;
}

if ( (menu = FindMenu(w, params[0])) == NULL) {
char error_buf[BUFSIZ];
sprintf(error_buf, "%s '%s'",
        "Xaw - SimpleMenuWidget: could not find menu named: ", params[0]);
XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
return;
}

switch (event->type) {
case ButtonPress:
case ButtonRelease:
loc.x = event->xbutton.x_root;
loc.y = event->xbutton.y_root;
PositionMenu(menu, &loc);
break;
case EnterNotify:
case LeaveNotify:
loc.x = event->xcrossing.x_root;
loc.y = event->xcrossing.y_root;
```



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```

    PositionMenu(menu, &loc);
    break;
case MotionNotify:
    loc.x = event->xmotion.x_root;
    loc.y = event->xmotion.y_root;
    PositionMenu(menu, &loc);
    break;
default:
    PositionMenu(menu, NULL);
    break;
}
}

```

```

/.....
*
* Widget Action Routines.
*
...../

```

```

/*  Function Name: Unhighlight
*  Description: Unhighlights current entry.
*  Arguments: w - the simple menu widget.
*              event - the event that caused this action.
*              params, num_params - ** NOT USED **
*  Returns: none
*/

```

```

/* ARGSUSED */

```

```

static void

```

```

Unhighlight(w, event, params, num_params)

```

```

Widget w:

```

```

XEvent * event:

```

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```

String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry = smw->simple_menu.entry_set;
    SmeObjectClass class;

    if ( entry == NULL) return;

    smw->simple_menu.entry_set = NULL;
    class = (SmeObjectClass) entry->object.widget_class;
    (class->sme_class.unhighlight) ( (Widget) entry);
}

```

```

/*  Function Name: Highlight
    *  Description: Highlights current entry.
    *  Arguments: w - the simple menu widget.
    *              event - the event that caused this action.
    *              params, num_params - ** NOT USED **
    *  Returns: none
*/

```

```

/* ARGSUSED */
static void
Highlight(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry;

```

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```
SmeObjectClass class;
```

```
if ( !XtIsSensitive(w) ) return;
```

```
entry = GetEventEntry(w, event);
```

```
if (entry == smw->simple_menu.entry_set) return;
```

```
Unhighlight(w, event, params, num_params);
```

```
if (entry == NULL) return;
```

```
if ( !XtIsSensitive( (Widget) entry)) {
    smw->simple_menu.entry_set = NULL;
    return;
}
```

```
smw->simple_menu.entry_set = entry;
class = (SmeObjectClass) entry->object.widget_class;
```

```
(class->sme_class.highlight) ( (Widget) entry);
```

```
}
```

```
/* Function Name: Notify
```

- Description: Notify user of current entry.
- Arguments: w - the simple menu widget.
- event - the event that caused this action.
- params, num\_params - \*\* NOT USED \*\*
- Returns: none

```
*/
```

```
/* ARGSUSED */
```

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```

static void
Notify(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry = smw->simple_menu.entry_set;
    SmeObjectClass class;

    if ( (entry == NULL) || !XIsSensitive((Widget) entry) ) return;

    class = (SmeObjectClass) entry->object.widget_class;
    (class->sme_class.notify)((Widget) entry );
}

/*  Function Name: Pull
    • Description: Determines action on basis of leave direction.
    • Arguments: w - the pull right menu widget.
    •             event - the LeaveWindow event that caused this action.
    •             params, num_params - ** NOT USED **
    • Returns: none
*/

```

```

static void Pull(w, event, params, num_params)

```

```

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

```

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```

{
    PullRightMenuWidget    prw=(PullRightMenuWidget)w;
    SmeObject    entry=prw->simple_menu.entry_set;
    SmeObjectClass    class;

    if ((entry == NULL) || !XtIsSensitive((Widget)entry))return;
    if (event->type != LeaveNotify && event->type != EnterNotify) {
        XtAppError(XtWidgetToApplicationContext(w),
            "pull() action should only be used with XCrossing events.");
        return;
    }
    if (None != event->xcrossing.subwindow) return;
    if (event->xcrossing.y < 0 || event->xcrossing.y > prw->core.height) {
        Unhighlight(w,event,params,num_params);
        return;
    };
    if (event->xcrossing.x < 0) {
        if (XtIsSubclass(XtParent(w),pullRightMenuWidgetClass)) XtPopdown(w);
        return;
    };
    class=(SmeObjectClass)entry->object.widget_class;
    if (event->xcrossing.x > prw->core.width &&
XtIsSubclass(entry,smeBSBprObjectClass)) (class->sme_class.notify)((Widget)entry);
    else Unhighlight(w,event,params,num_params);
}

```

/\* Function Name: Execute

- Description: Determines notify action on basis of SmeObject.
- Arguments: w - the pull right menu widget.
- event - the notify-type event that caused this action.
- params. num\_params - \*\* NOT USED \*\*
- Returns: none

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```

*/

static void Execute(w, event, params, num_params)

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

{
    PullRightMenuWidget    prw = (PullRightMenuWidget)w;
    SmeObject    entry = prw->simple_menu.entry_set;
    SmeObjectClass    class;
    Widget    shell;

    Dprintf("Execute\n");
    for(shell = w; XtIsSubclass(shell, pullRightMenuWidgetClass); shell = XtParent(shell))
    {
        XawSimpleMenuClearActiveEntry(shell);
        XtPopdown(shell);
    };
    if
    ((entry == GetEventEntry(w, event)) && (entry != NULL) && XtIsSensitive((Widget)entry)) {
        class = (SmeObjectClass)entry->object.widget_class;
        if (XtIsSubclass(entry, smeBSBObjectClass))
        (class->sme_class.notify)((Widget)entry);
    };
}

```

```

/.....

```

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•

• Public Functions.

•

...../

```

/*    Function Name: XawPullRightMenuAddGlobalActions
*    Description: adds the global actions to the simple menu widget.
*    Arguments: app_con - the appcontext.
*    Returns: none.
*/

```

```

void
XawPullRightMenuAddGlobalActions(app_con)
XtAppContext app_con;
{
    XtInitializeWidgetClass(pullRightMenuWidgetClass);
    XmuCallInitializers( app_con );
}

```

/.....

•

• Private Functions.

•

...../

```

/*    Function Name: CreateLabel
*    Description: Creates a the menu label.
*    Arguments: w - the smw widget.
*    Returns: none.
*
*    Creates the label object and makes sure it is the first child in
*    in the list.

```

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\*/

static void

CreateLabel(w)

Widget w;

{

SimpleMenuWidget smw = (SimpleMenuWidget) w;

register Widget \* child, \* next\_child;

register int i;

Arg args[2];

if ( (smw-&gt;simple\_menu.label\_string == NULL) ||

(smw-&gt;simple\_menu.label != NULL) ) {

char error\_buf[BUFSIZ];

sprintf(error\_buf, "Xaw Simple Menu Widget: %s or %s, %s",

"label string is NULL", "label already exists",

"no label is being created.");

XtAppWarning(XtWidgetToApplicationContext(w), error\_buf);

return;

}

XtSetArg(args[0], XtNlabel, smw-&gt;simple\_menu.label\_string);

XtSetArg(args[1], XtNjustify, XtJustifyCenter);

smw-&gt;simple\_menu.label = (SmeObject)

XtCreateManagedWidget("menuLabel",

smw-&gt;simple\_menu.label\_class, w,

args, TWO);

next\_child = NULL;

for (child = smw-&gt;composite.children + smw-&gt;composite.num\_children,

i = smw-&gt;composite.num\_children ; i &gt; 0 ; i--, child--) {



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```

    if (next_child != NULL)
        *next_child = *child;
    next_child = child;
}
*child = (Widget) smw->simple_menu.label;
}

/*  Function Name: Layout
 *  Description: lays the menu entries out all nice and neat.
 *  Arguments: w - See below (+++)
 *              width_ret, height_ret - The returned width and
 *                                      height values.
 *  Returns: none.
 *
 *  if width == NULL || height == NULL then it assumes the you do not care
 *  about the return values, and just want a relayout.
 *
 *  if this is not the case then it will set width_ret and height_ret
 *  to be width and height that the child would get if it were layed out
 *  at this time.
 *
 *  +++ "w" can be the simple menu widget or any of its object children.
 */

```

static void

Layout(w, width\_ret, height\_ret)

Widget w;

Dimension \*width\_ret, \*height\_ret;

```

{
    SmeObject current_entry, *entry;
    SimpleMenuWidget smw;
    Dimension width, height;

```

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```
Boolean do_layout = ((height_ret == NULL) || (width_ret == NULL));
```

```
Boolean allow_change_size;
```

```
height = 0;
```

```
if ( XtIsSubclass(w, puliRightMenuWidgetClass) ) {
```

```
    smw = (SimpleMenuWidget) w;
```

```
    current_entry = NULL;
```

```
}
```

```
else {
```

```
    smw = (SimpleMenuWidget) XtParent(w);
```

```
    current_entry = (SmeObject) w;
```

```
}
```

```
allow_change_size = (!XtIsRealized((Widget)smw) ||
```

```
    (smw->shell.allow_shell_resize));
```

```
if ( smw->simple_menu.menu_height )
```

```
    height = smw->core.height;
```

```
else
```

```
    if (do_layout) {
```

```
        height = smw->simple_menu.top_margin;
```

```
        ForAllChildren(smw, entry) {
```

```
            if (!XtIsManaged( (Widget) *entry)) continue;
```

```
            if ( (smw->simple_menu.row_height != 0) &&
```

```
                (*entry != smw->simple_menu.label) )
```

```
                (*entry)->rectangle.height = smw->simple_menu.row_height;
```

```
            (*entry)->rectangle.y = height;
```

```
            (*entry)->rectangle.x = 0;
```

```
            height += (*entry)->rectangle.height;
```

```
        }
```

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```

        height += smw->simple_menu.bottom_margin;
    }
    else {
        if ((smw->simple_menu.row_height != 0) &&
            (current_entry != smw->simple_menu.label) )
            height = smw->simple_menu.row_height;
    }

    if (smw->simple_menu.menu_width)
        width = smw->core.width;
    else if ( allow_change_size )
        width = GetMenuWidth((Widget) smw, (Widget) current_entry);
    else
        width = smw->core.width;

    if (do_layout) {
        ForAllChildren(smw, entry)
            if (XIsManaged( (Widget) *entry))
                (*entry)->rectangle.width = width;

        if (allow_change_size)
            MakeSetValuesRequest((Widget) smw, width, height);
    }
    else {
        *width_ret = width;
        if (height != 0)
            *height_ret = height;
    }
}

```

/\* Function Name: AddPositionAction

\* Description: Adds the XawPositionSimpleMenu action to the global

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- action list for this appcon.
- Arguments: app\_con - the application context for this app.
- data - NOT USED.
- Returns: none.
- \*/

/\* ARGSUSED \*/

static void

AddPositionAction(app\_con, data)

XtAppContext app\_con;

caddr\_t data;

{

```
static XtActionsRec pos_action[] = {
    { "XawPositionSimpleMenu", PositionMenuAction },
};
```

XtAppAddActions(app\_con, pos\_action, XtNumber(pos\_action));

}

/\* Function Name: FindMenu

- Description: Find the menu give a name and reference widget.
- Arguments: widget - reference widget.
- name - the menu widget's name.
- Returns: the menu widget or NULL.
- \*/

static Widget

FindMenu(widget, name)

Widget widget;

String name;

{

register Widget w, menu;

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```

for ( w = widget ; w != NULL ; w = XtParent(w) )
    if ( (menu = XtNameToWidget(w, name)) != NULL )
        return(menu);
return(NULL);
}

```

```

/*      Function Name: PositionMenu
*      Description: Places the menu
*      Arguments: w - the simple menu widget.
*                  location - a pointer the the position or NULL.
*      Returns: none.
*/

```

```
static void
```

```
PositionMenu(w, location)
```

```
Widget w;
```

```
XPoint * location;
```

```
{
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    SmeObject entry;
```

```
    XPoint t_point;
```

```
    static void MoveMenu();
```

```
    if (location == NULL) {
```

```
        Window junk1, junk2;
```

```
        int root_x, root_y, junkX, junkY;
```

```
        unsigned int junkM;
```

```
        location = &t_point;
```

```
        if (XQueryPointer(XtDisplay(w), XtWindow(w), &junk1, &junk2,
                        &root_x, &root_y, &junkX, &junkY, &junkM) == FALSE) {
```

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```

char error_buf[BUFSIZ];
sprintf(error_buf, "%s %s", "Xaw - SimpleMenuWidget:",
        "Could not find location of mouse pointer");
XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
return;
}
location->x = (short) root_x;
location->y = (short) root_y;
}

```

```

/*
 * The width will not be correct unless it is realized.
 */

```

```

XtRealizeWidget(w);

```

```

location->x -= (Position) w->core.width/2;

```

```

if (smw->simple_menu.popup_entry == NULL)

```

```

    entry = smw->simple_menu.label;

```

```

else

```

```

    entry = smw->simple_menu.popup_entry;

```

```

if (entry != NULL)

```

```

    location->y -= entry->rectangle.y + entry->rectangle.height/2;

```

```

MoveMenu(w, (Position) location->x, (Position) location->y);

```

```

}

```

```

/* Function Name: MoveMenu

```

- \* Description: Actually moves the menu, may force it to
- \* to be fully visible if menu\_on\_screen is TRUE.

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- Arguments: w - the simple menu widget.
- x, y - the current location of the widget.
- Returns: none
- /

```
static void
```

```
MoveMenu(w, x, y)
```

```
Widget w;
```

```
Position x, y;
```

```
{
```

```
    Arg arglist[2];
```

```
    Cardinal num_args = 0;
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    if (smw->simple_menu.menu_on_screen) {
```

```
        int width = w->core.width + 2 * w->core.border_width;
```

```
        int height = w->core.height + 2 * w->core.border_width;
```

```
        if (x < 0)
```

```
            x = 0;
```

```
        else {
```

```
            int scr_width = WidthOfScreen(XtScreen(w));
```

```
            if (x + width > scr_width)
```

```
                x = scr_width - width;
```

```
        }
```

```
        if (y < 0)
```

```
            y = 0;
```

```
        else {
```

```
            int scr_height = HeightOfScreen(XtScreen(w));
```

```
            if (y + height > scr_height)
```

```
                y = scr_height - height;
```

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```

    }
}

```

```

XtSetArg(arglist[num_args], XtNx, x); num_args++;
XtSetArg(arglist[num_args], XtNy, y); num_args++;
XtSetValues(w, arglist, num_args);

```

```

}

```

```

/*      Function Name: ChangeCursorOnGrab
*      Description: Changes the cursor on the active grab to the one
*                  specified in out resource list.
*      Arguments: w - the widget.
*                  junk, garbage - ** NOT USED **.
*      Returns: None.
*/

```

```

/* ARGSUSED */

```

```

static void

```

```

ChangeCursorOnGrab(w, junk, garbage)

```

```

Widget w;

```

```

caddr_t junk, garbage;

```

```

{

```

```

    SimpleMenuWidget smw = (SimpleMenuWidget) w;

```

```

/*

```

- \* The event mask here is what is currently in the MIT implementation.
  - \* There really needs to be a way to get the value of the mask out
  - \* of the toolkit (CDP 5/26/89).
- ```

*/

```

```

XChangeActivePointerGrab(XtDisplay(w), ButtonPressMask | ButtonReleaseMask,
                          smw->simple_menu.cursor, CurrentTime);

```



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}

```

/*  Function Name: MakeSetValuesRequest
    *  Description: Makes a (possibly recursive) call to SetValues,
    *               I take great pains to not go into an infinite loop.
    *  Arguments: w - the simple menu widget.
    *               width, height - the size of the ask for.
    *  Returns: none
    */

```

```

static void

```

```

MakeSetValuesRequest(w, width, height)

```

```

Widget w;

```

```

Dimension width, height;

```

```

{

```

```

    SimpleMenuWidget smw = (SimpleMenuWidget) w;

```

```

    Arg arglist[2];

```

```

    Cardinal num_args = (Cardinal) 0;

```

```

    if ( !smw->simple_menu.recursive_set_values ) {

```

```

        if ( (smw->core.width != width) || (smw->core.height != height) ) {

```

```

            smw->simple_menu.recursive_set_values = TRUE;

```

```

            XtSetArg(arglist[num_args], XtNwidth, width);  num_args++;

```

```

            XtSetArg(arglist[num_args], XtNheight, height); num_args++;

```

```

            XtSetValues(w, arglist, num_args);

```

```

        }

```

```

        else if (XtIsRealized( (Widget) smw))

```

```

            Redisplay((Widget) smw, (XEvent *) NULL, (Region) NULL);

```

```

    }

```

```

    smw->simple_menu.recursive_set_values = FALSE;

```

```

}

```

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```

/*    Function Name: GetMenuWidth
 *    Description: Sets the length of the widest entry in pixels.
 *    Arguments: w - the simple menu widget.
 *    Returns: width of menu.
 */

```

```
static Dimension
```

```
GetMenuWidth(w, w_ent)
```

```
Widget w, w_ent;
```

```
{
```

```
    SmeObject cur_entry = (SmeObject) w_ent;
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    Dimension width, widest = (Dimension) 0;
```

```
    SmeObject * entry;
```

```
    if ( smw->simple_menu.menu_width )
```

```
        return(smw->core.width);
```

```
    ForAllChildren(smw, entry) {
```

```
        XtWidgetGeometry preferred;
```

```
        if (!XtIsManaged( (Widget) *entry)) continue;
```

```
        if (*entry != cur_entry) {
```

```
            XtQueryGeometry(*entry, NULL, &preferred);
```

```
            if (preferred.request_mode & CWWidth)
```

```
                width = preferred.width;
```

```
            else
```

```
                width = (*entry)->rectangle.width;
```

```
        }
```

```
    else
```

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```

        width = (*entry)->rectangle.width;

        if ( width > widest )
            widest = width;
    }

    return(widest);
}

/*    Function Name: GetMenuHeight
 *    Description: Sets the length of the widest entry in pixels.
 *    Arguments: w - the simple menu widget.
 *    Returns: width of menu.
 */

static Dimension
GetMenuHeight(w)
Widget w;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;
    Dimension height;

    if (smw->simple_menu.menu_height)
        return(smw->core.height);

    height = smw->simple_menu.top_margin + smw->simple_menu.bottom_margin;

    if (smw->simple_menu.row_height == 0)
        ForAllChildren(smw, entry)
            if (XtIsManaged ((Widget) *entry))
                height += (*entry)->rectangle.height;

```

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```

else
    height += smw->simple_menu.row_height * smw->composite.num_children;

return(height);
}

```

```

/*  Function Name: GetEventEntry
    *  Description: Gets an entry given an event that has X and Y coords.
    *  Arguments: w - the simple menu widget.
    *              event - the event.
    *  Returns: the entry that this point is in.
    */

```

```

static SmeObject
GetEventEntry(w, event)
Widget w;
XEvent * event;
{
    Position x_loc, y_loc;
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;

    switch (event->type) {
    case MotionNotify:
        x_loc = event->xmotion.x;
        y_loc = event->xmotion.y;
        break;
    case EnterNotify:
    case LeaveNotify:
        x_loc = event->xcrossing.x;
        y_loc = event->xcrossing.y;
        break;
    }
}

```

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```
case BunonPress:
```

```
case BunonRelease:
```

```
    x_loc = event->xbunon.x;
```

```
    y_loc = event->xbunon.y;
```

```
    break;
```

```
default:
```

```
    XtAppError(XtWidgetToApplicationContext(w),
```

```
                "Unknown event type in GetEventEntry().");
```

```
    break;
```

```
}
```

```
if ( (x_loc < 0) || (x_loc >= smw->core.width) || (y_loc < 0) ||
```

```
    (y_loc >= smw->core.height) )
```

```
    return(NULL);
```

```
ForAllChildren(smw, entry) {
```

```
    if (!XtIsManaged ((Widget) *entry)) continue;
```

```
    if ( ((*entry)->rectangle.y < y_loc) &&
```

```
        ((*entry)->rectangle.y + (*entry)->rectangle.height > y_loc) )
```

```
        if ( *entry == smw->simple_menu.label )
```

```
            return(NULL);    /* cannot select the label. */
```

```
        else
```

```
            return(*entry);
```

```
}
```

```
return(NULL);
```

```
}
```

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source/Select.c

```

/*
 * Selection from list widget
 *
 */

#include    "../include/xwave.h"

void  Select(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Selection    sel=(Selection)closure;
    Widget       bunon=FindWidget(sel->bunon,w),
               shell=ShellWidget(sel->name,bunon,SW_below,NULL,NULL),
               form=FormatWidget("sel_form",shell), list_widget, widgets[3];
    String *list=(sel->list_proc)();
    FormItem     items[]={
        {"sel_cancel","close",0,0,FW_icon,NULL},
        {"sel_label",(String)sel->action_name,1,0,FW_label,NULL},
        {"sel_view",NULL,0,2,FW_view,NULL},
    };
    XtCallbackRec list_calls[]={
        {Destroy,(caddr_t)shell},
        {sel->action_proc,sel->action_closure},
        {NULL,NULL},
    }, callbacks[]={

```

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```
        {Destroy,(caddr_t)shell},
        {NULL,NULL},
    };
    Arg    args[1];

    FillForm(form,THREE,items,widgets,callbacks);
    XtSetArg(args[0],XtNlist,list);

list_widget=XtCreateManagedWidget("sel_list",listWidgetClass,widgets[2],args,ONE);
    XtAddCallbacks(list_widget,XtNcallback,list_calls);
    XtPopup(shell,XtGrabExclusive);
}
```

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source/SmeBSBpr.c

#if ( !defined(lint) &amp;&amp; !defined(SABER) )

static char Xrclid[] = "\$XConsortium: SmeBSB.c,v 1.9 89/12/13 15:42:48 kit Exp \$";

#endif

/\*

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- 
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OF OR IN
- CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.



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\*/

/\*

- SmeBSBpr.c - Source code file for BSB pull-right Menu Entry object.

•

\*/

#include &lt;stdio.h&gt;

#include &lt;X11/IntrinsicP.h&gt;

#include &lt;X11/StringDefs.h&gt;

#include &lt;X11/Xmu/Drawing.h&gt;

#include &lt;X11/Xaw/XawInit.h&gt;

#include &lt;X11/Xaw/SimpleMenu.h&gt;

#include "SmeBSBprP.h"

#include &lt;X11/Xaw/Cardinals.h&gt;

#define ONE\_HUNDRED 100

#define offset(field) XtOffset(SmeBSBprObject, sme\_bsb.field)

static XtResource resources[] = {

- {XtNlabel, XtCLabel, XtRString, sizeof(String),
- offset(label), XtRString, NULL},

- {XtNvertSpace, XtCVertSpace, XtRInt, sizeof(int),
- offset(vert\_space), XtRImmediate, (caddr\_t) 25},

- {XtNleftBitmap, XtCLeftBitmap, XtRPixmap, sizeof(Pixmap),
- offset(left\_bitmap), XtRImmediate, (caddr\_t)None},

- {XtNjustify, XtCJustify, XtRJustify, sizeof(XtJustify),
- offset(justify), XtRImmediate, (caddr\_t) XtJustifyLeft},

- {XtNrightBitmap, XtCRightBitmap, XtRPixmap, sizeof(Pixmap),

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```

        offset(right_bitmap), XtRImmediate, (caddr_t)None},
    {XtNleftMargin, XtCHorizontalMargins, XtRDimension, sizeof(Dimension),
        offset(left_margin), XtRImmediate, (caddr_t) 4},
    {XtNrightMargin, XtCHorizontalMargins, XtRDimension, sizeof(Dimension),
        offset(right_margin), XtRImmediate, (caddr_t) 4},
    {XtNforeground, XtCForeground, XtRPixel, sizeof(Pixel),
        offset(foreground), XtRString, "XtDefaultForeground"},
    {XtNfont, XtCFont, XtRFontStruct, sizeof(XFontStruct *),
        offset(font), XtRString, "XtDefaultFont"},
    {XtNmenuName, XtCMenuName, XtRString, sizeof(String),
        offset(menu_name), XtRString, (caddr_t)"menu"},
};
#undef offset

/*
 * Semi Public function definitions.
 */

static void Redisplay(), Destroy(), Initialize(), FlipColors(), PopupMenu();
static void ClassInitialize();
static Boolean SetValues();
static XtGeometryResult QueryGeometry();

/*
 * Private Function Definitions.
 */

static void GetDefaultSize(), DrawBitmaps(), GetBitmapInfo();
static void CreateGCs(), DestroyGCs();

#define superclass (&smeClassRec)
SmeBSBprClassRec smeBSBprClassRec = {

```

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```
{
/* superclass      */ (WidgetClass) superclass,
/* class_name      */ "SmeBSBpr",
/* size            */ sizeof(SmeBSBprRec),
/* class_initializer */ ClassInitialize,
/* class_part_initialize */ NULL,
/* Class init'ed    */ FALSE,
/* initialize       */ Initialize,
/* initialize_hook   */ NULL,
/* realize          */ NULL,
/* actions          */ NULL,
/* num_actions      */ ZERO,
/* resources        */ resources,
/* resource_count    */ XtNumber(resources),
/* xrm_class        */ NULLQUARK,
/* compress_motion   */ FALSE,
/* compress_exposure */ FALSE,
/* compress_enterleave */ FALSE,
/* visible_interest */ FALSE,
/* destroy          */ Destroy,
/* resize          */ NULL,
/* expose          */ Redisplay,
/* set_values       */ SetValues,
/* set_values_hook   */ NULL,
/* set_values_almost */ XtInheritSetValuesAlmost,
/* get_values_hook   */ NULL,
/* accept_focus     */ NULL,
/* intrinsics version */ XtVersion,
/* callback offsets  */ NULL,
/* tm_table         */ NULL,
/* query_geometry    */ QueryGeometry,
/* display_accelerator */ NULL,
```

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```

    /* extension      */ NULL
}.{
    /* Menu Entry Fields */

    /* highlight */      FlipColors,
    /* unhighlight */    FlipColors,
    /* notify */        PopupMenu,
    /* extension      */ NULL
}. {
    /* BSB pull-right Menu entry Fields */

    /* extension      */ NULL
}
};

WidgetClass smeBSBprObjectClass = (WidgetClass) &smeBSBprClassRec;

/*****
 *
 * Semi-Public Functions.
 *
 *****/

/*    Function Name: ClassInitialize
 *    Description: Initializes the SmeBSBprObject.
 *    Arguments: none.
 *    Returns: none.
 */

static void
ClassInitialize()
{

```

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```
XawInitializeWidgetSet();
XtAddConverter( XtRString, XtRJustify, XmuCvtStringToJustify, NULL, 0 );
}

/* Function Name: Initialize
 * Description: Initializes the simple menu widget
 * Arguments: request - the widget requested by the argument list.
 *            new      - the new widget with both resource and non
 *                      resource values.
 * Returns: none.
 */

/* ARGSUSED */
static void
Initialize(request, new)
Widget request, new;
{
    SmeBSBprObject entry = (SmeBSBprObject) new;

    if (entry->sme_bsb.label == NULL)
        entry->sme_bsb.label = XtName(new);
    else
        entry->sme_bsb.label = XtNewString( entry->sme_bsb.label );

    /* Xaw bug - bitmap initialization now performed */
    if (entry->sme_bsb.left_bitmap != None) GetBitmapInfo(entry, TRUE);
    if (entry->sme_bsb.right_bitmap != None) GetBitmapInfo(entry, FALSE);

    CreateGCs(new);
    GetDefaultSize(new, &(entry->rectangle.width), &(entry->rectangle.height));
}
```

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```

/*  Function Name: Destroy
 *   Description: Called at destroy time, cleans up.
 *   Arguments: w - the simple menu widget.
 *   Returns: none.
 */

```

```

static void
Destroy(w)
Widget w;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;

    DestroyGCs(w);
    if (entry->sme_bsb.label != XtName(w))
        XtFree(entry->sme_bsb.label);
}

```

```

/*  Function Name: Redisplay
 *   Description: Redisplays the contents of the widget.
 *   Arguments: w - the simple menu widget.
 *               event - the X event that caused this redisplay.
 *               region - the region the needs to be repainted.
 *   Returns: none.
 */

```

```

/* ARGSUSED */

```

```

static void
Redisplay(w, event, region)
Widget w;
XEvent * event;
Region region;
{

```

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GC gc;

SmeBSBprObject entry = (SmeBSBprObject) w;

int font\_ascent, font\_descent, y\_loc;

entry->sme\_bsb.set\_values\_area\_cleared = FALSE;

font\_ascent = entry->sme\_bsb.font->max\_bounds.ascent;

font\_descent = entry->sme\_bsb.font->max\_bounds.descent;

y\_loc = entry->rectangle.y;

if (XtIsSensitive(w) && XtIsSensitive( XtParent(w) ) ) {

if ( w == XawSimpleMenuGetActiveEntry(XtParent(w)) ) {

XFillRectangle(XtDisplayOfObject(w), XtWindowOfObject(w),

entry->sme\_bsb.norm\_gc, 0, y\_loc,

(unsigned int) entry->rectangle.width,

(unsigned int) entry->rectangle.height);

gc = entry->sme\_bsb.rev\_gc;

}

else

gc = entry->sme\_bsb.norm\_gc;

}

else

gc = entry->sme\_bsb.norm\_gray\_gc;

if (entry->sme\_bsb.label != NULL) {

int x\_loc = entry->sme\_bsb.left\_margin;

int len = strlen(entry->sme\_bsb.label);

char \* label = entry->sme\_bsb.label;

switch(entry->sme\_bsb.justify) {

int width, t\_width;

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```
case XtJustifyCenter:
```

```
    t_width = XTextWidth(entry->sme_bsb.font, label, len);
```

```
    width = entry->rectangle.width - (entry->sme_bsb.left_margin +
                                      entry->sme_bsb.right_margin);
```

```
    x_loc += (width - t_width)/2;
```

```
    break;
```

```
case XtJustifyRight:
```

```
    t_width = XTextWidth(entry->sme_bsb.font, label, len);
```

```
    x_loc = entry->rectangle.width - (entry->sme_bsb.right_margin +
                                      t_width);
```

```
    break;
```

```
case XtJustifyLeft:
```

```
default:
```

```
    break;
```

```
}
```

```
y_loc += (entry->rectangle.height -
          (font_ascent + font_descent)) / 2 + font_ascent;
```

```
XDrawString(XtDisplayOfObject(w), XtWindowOfObject(w), gc,
            x_loc, y_loc, label, len);
```

```
}
```

```
DrawBitmaps(w, gc);
```

```
}
```

```
/* Function Name: SetValues
```

- \* Description: Relayout the menu when one of the resources is changed.
- \* Arguments: current - current state of the widget.
- \* request - what was requested.
- \* new - what the widget will become.



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- Returns: none

\*/

/\* ARGSUSED \*/

static Boolean

SetValues(current, request, new)

Widget current, request, new;

{

SmeBSBprObject entry = (SmeBSBprObject) new;

SmeBSBprObject old\_entry = (SmeBSBprObject) current;

Boolean ret\_val = FALSE;

if (old\_entry-&gt;sme\_bsb.label != entry-&gt;sme\_bsb.label) {

if (old\_entry-&gt;sme\_bsb.label != XtName( new ) )

XtFree( (char \*) old\_entry-&gt;sme\_bsb.label );

if (entry-&gt;sme\_bsb.label != XtName(new) )

entry-&gt;sme\_bsb.label = XtNewString( entry-&gt;sme\_bsb.label );

ret\_val = True;

}

if (entry-&gt;rectangle.sensitive != old\_entry-&gt;rectangle.sensitive )

ret\_val = TRUE;

if (entry-&gt;sme\_bsb.left\_bitmap != old\_entry-&gt;sme\_bsb.left\_bitmap) {

GetBitmapInfo(new, TRUE);

ret\_val = TRUE;

}

if (entry-&gt;sme\_bsb.right\_bitmap != old\_entry-&gt;sme\_bsb.right\_bitmap) {

GetBitmapInfo(new, FALSE);

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```

    ret_val = TRUE;
}

if ( (old_entry->sme_bsb.font != entry->sme_bsb.font) ||
      (old_entry->sme_bsb.foreground != entry->sme_bsb.foreground) ) {
    DestroyGCs(current);
    CreateGCs(new);
    ret_val = TRUE;
}

if (ret_val) {
    GetDefaultSize(new,
                   &(entry->rectangle.width), &(entry->rectangle.height));
    entry->sme_bsb.set_values_area_cleared = TRUE;
}
return(ret_val);
}

/*  Function Name: QueryGeometry.
*
*  Description: Returns the preferred geometry for this widget.
*
*  Arguments: w - the menu entry object.
*
*             intended, return_val - the intended and return geometry info.
*
*  Returns: A Geometry Result.
*
*
*  See the Intrinsics manual for details on what this function is for.
*
*  I just return the height and width of the label plus the margins.
*/

```

```

static XtGeometryResult
QueryGeometry(w, intended, return_val)
Widget w;

```

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```
XtWidgetGeometry *intended, *return_val;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;
    Dimension width, height;
    XtGeometryResult ret_val = XtGeometryYes;
    XtGeometryMask mode = intended->request_mode;

    GetDefaultSize(w, &width, &height );

    if ( ((mode & CWWidth) && (intended->width != width)) ||
        !(mode & CWWidth) ) {
        return_val->request_mode |= CWWidth;
        return_val->width = width;
        ret_val = XtGeometryAlmost;
    }

    if ( ((mode & CWHeight) && (intended->height != height)) ||
        !(mode & CWHeight) ) {
        return_val->request_mode |= CWHeight;
        return_val->height = height;
        ret_val = XtGeometryAlmost;
    }

    if (ret_val == XtGeometryAlmost) {
        mode = return_val->request_mode;

        if ( ((mode & CWWidth) && (width == entry->rectangle.width)) &&
            ((mode & CWHeight) && (height == entry->rectangle.height)) )
            return(XtGeometryNo);
    }

    return(ret_val);
}
```

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}

/\* Function Name: FlipColors

\* Description: Invert the colors of the current entry.

\* Arguments: w - the bsb menu entry widget.

\* Returns: none.

\*/

static void

FlipColors(w)

Widget w;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

if (entry-&gt;sme\_bsb.set\_values\_area\_cleared) return;

XFillRectangle(XtDisplayOfObject(w), XtWindowOfObject(w),

entry-&gt;sme\_bsb.invert\_gc, 0, (int) entry-&gt;rectangle.y,

(unsigned int) entry-&gt;rectangle.width,

(unsigned int) entry-&gt;rectangle.height);

}

/\*\*\*\*\*

\*

\* Private Functions.

\*

\*\*\*\*\*/

/\* Function Name: GetDefaultSize

\* Description: Calculates the Default (preferred) size of

\* this menu entry.

\* Arguments: w - the menu entry widget.

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- \* width, height - default sizes (RETURNED).
- \* Returns: none.
- \*/

static void

GetDefaultSize(w, width, height)

Widget w;

Dimension \* width, \* height;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

if (entry->sme\_bsb.label == NULL)

    \*width = 0;

else

    \*width = XTextWidth(entry->sme\_bsb.font, entry->sme\_bsb.label,  
                        strlen(entry->sme\_bsb.label));

    \*width += entry->sme\_bsb.left\_margin + entry->sme\_bsb.right\_margin;

    \*height = (entry->sme\_bsb.font->max\_bounds.ascent +  
              entry->sme\_bsb.font->max\_bounds.descent);

    \*height = (\*height \* ( ONE\_HUNDRED +  
                        entry->sme\_bsb.vert\_space )) / ONE\_HUNDRED;

}

/\* Function Name: DrawBitmaps

- \* Description: Draws left and right bitmaps.
- \* Arguments: w - the simple menu widget.
- \* gc - graphics context to use for drawing.
- \* Returns: none
- \*/

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```
static void
DrawBitmaps(w, gc)
Widget w;
GC gc;
{
    int x_loc, y_loc;
    SmeBSBprObject entry = (SmeBSBprObject) w;

    if ( (entry->sme_bsb.left_bitmap == None) &&
        (entry->sme_bsb.right_bitmap == None) ) return;

/*
 * Draw Left Bitmap.
 */

    y_loc = entry->rectangle.y + (entry->rectangle.height -
                                   entry->sme_bsb.left_bitmap_height) / 2;

    if (entry->sme_bsb.left_bitmap != None) {
        x_loc = (entry->sme_bsb.left_margin -
                 entry->sme_bsb.left_bitmap_width) / 2;
        XCopyPlane(XtDisplayOfObject(w), entry->sme_bsb.left_bitmap,
                   XtWindowOfObject(w), gc, 0, 0,
                   entry->sme_bsb.left_bitmap_width,
                   entry->sme_bsb.left_bitmap_height, x_loc, y_loc, 1);
    }

/*
 * Draw Right Bitmap.
 */

    y_loc = entry->rectangle.y + (entry->rectangle.height - /* Xaw bug - y_loc
```

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calculated from right\_bitmap data \*/

entry->sme\_bsb.right\_bitmap\_height) / 2;

if (entry->sme\_bsb.right\_bitmap != None) {

x\_loc = entry->rectangle.width - (entry->sme\_bsb.right\_margin + /\* Xaw bug - +  
rather than - sign \*/

entry->sme\_bsb.right\_bitmap\_width) / 2;

XCopyPlane(XtDisplayOfObject(w), entry->sme\_bsb.right\_bitmap,

XtWindowOfObject(w), gc, 0, 0,

entry->sme\_bsb.right\_bitmap\_width,

entry->sme\_bsb.right\_bitmap\_height, x\_loc, y\_loc, 1);

}

}

/\* Function Name: GetBitmapInfo

\* Description: Gets the bitmap information from either of the bitmaps.

\* Arguments: w - the bsb menu entry widget.

\* is\_left - TRUE if we are testing left bitmap,

\* FALSE if we are testing the right bitmap.

\* Returns: none

\*/

static void

GetBitmapInfo(w, is\_left)

Widget w;

Boolean is\_left;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

unsigned int depth, bw;

Window root;

int x, y;

unsigned int width, height;

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```
char buf[BUFSIZ];
```

```
if (is_left) {
```

```
    if (entry->sme_bsb.left_bitmap != None) {
```

```
        if (!XGetGeometry(XtDisplayOfObject(w),
```

```
            entry->sme_bsb.left_bitmap, &root,
```

```
            &x, &y, &width, &height, &bw, &depth)) {
```

```
            sprintf(buf, "SmeBSB Object: %s %s \"%s\".", "Could not",
```

```
                "get Left Bitmap geometry information for menu entry ",
```

```
                XtName(w));
```

```
            XtAppError(XtWidgetToApplicationContext(w), buf);
```

```
        }
```

```
    if (depth != 1) {
```

```
        sprintf(buf, "SmeBSB Object: %s \"%s\" \"%s\".",
```

```
            "Left Bitmap of entry ",
```

```
            XtName(w), " is not one bit deep.");
```

```
        XtAppError(XtWidgetToApplicationContext(w), buf);
```

```
    }
```

```
    entry->sme_bsb.left_bitmap_width = (Dimension) width;
```

```
    entry->sme_bsb.left_bitmap_height = (Dimension) height;
```

```
}
```

```
}
```

```
else if (entry->sme_bsb.right_bitmap != None) {
```

```
    if (!XGetGeometry(XtDisplayOfObject(w),
```

```
        entry->sme_bsb.right_bitmap, &root,
```

```
        &x, &y, &width, &height, &bw, &depth)) {
```

```
        sprintf(buf, "SmeBSB Object: %s %s \"%s\".", "Could not",
```

```
            "get Right Bitmap geometry information for menu entry ",
```

```
            XtName(w));
```

```
        XtAppError(XtWidgetToApplicationContext(w), buf);
```

```
    }
```

```
    if (depth != 1) {
```



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```

    sprintf(buf, "SmeBSB Object: %s \"%s\" \"%s\".",
        "Right Bitmap of entry ", XtName(w),
        " is not one bit deep.");
    XtAppError(XtWidgetToApplicationContext(w), buf);
}
entry->sme_bsb.right_bitmap_width = (Dimension) width;
entry->sme_bsb.right_bitmap_height = (Dimension) height;
}
}

```

/\* Function Name: CreateGCs

- Description: Creates all gc's for the simple menu widget.
- Arguments: w - the simple menu widget.
- Returns: none.
- /

static void

CreateGCs(w)

Widget w;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

XGCValues values;

XtGCMask mask;

values.foreground = XtParent(w)->core.background\_pixel;

values.background = entry->sme\_bsb.foreground;

values.font = entry->sme\_bsb.font->fid;

values.graphics\_exposures = FALSE;

mask = GCForeground | GCBackground | GCFont | GCGraphicsExposures;

entry->sme\_bsb.rev\_gc = XtGetGC(w, mask, &values);

values.foreground = entry->sme\_bsb.foreground;

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```
values.background = XtParent(w)->core.background_pixel;
```

```
entry->sme_bsb.norm_gc = XtGetGC(w, mask, &values);
```

```
values.fill_style = FillTiled;
```

```
values.tile = XmuCreateStippledPixmap(XtScreenOfObject(w),
                                       entry->sme_bsb.foreground,
                                       XtParent(w)->core.background_pixel,
                                       XtParent(w)->core.depth);
```

```
values.graphics_exposures = FALSE;
```

```
mask |= GCTile | GCFillStyle;
```

```
entry->sme_bsb.norm_gray_gc = XtGetGC(w, mask, &values);
```

```
values.foreground ^= values.background;
```

```
values.background = 0;
```

```
values.function = GXxor;
```

```
mask = GCForeground | GCBackground | GCGraphicsExposures | GCFunction;
```

```
entry->sme_bsb.invert_gc = XtGetGC(w, mask, &values);
```

```
}
```

```
/* Function Name: DestroyGCs
```

```
 * Description: Removes all gc's for the simple menu widget.
```

```
 * Arguments: w - the simple menu widget.
```

```
 * Returns: none.
```

```
*/
```

```
static void
```

```
DestroyGCs(w)
```

```
Widget w;
```

```
{
```

```
    SmeBSBprObject entry = (SmeBSBprObject) w;
```

```
    XtReleaseGC(w, entry->sme_bsb.norm_gc);
```

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```

    XtReleaseGC(w, entry->sme_bsb.norm_gray_gc);
    XtReleaseGC(w, entry->sme_bsb.rev_gc);
    XtReleaseGC(w, entry->sme_bsb.invert_gc);
}

#ifdef apollo

/*
 * The apollo compiler that we have optimizes out my code for
 * FlipColors() since it is static. and no one executes it in this
 * file. I am setting the function pointer into the class structure so
 * that it can be called by my parent who will tell me to when to
 * highlight and unhighlight.
 */

void _XawSmeBSBApolloHack ()
{
    FlipColors();
}

#endif /* apollo */

/* Hacked copy of PopupMenu from MenuButton widget to replace XInheritNotify */

static void
PopupMenu(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SmeBSBprObject mbw = (SmeBSBprObject) w;
    Widget menu, temp;

```

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```
Arg arglist[2];
```

```
Cardinal num_args;
```

```
int menu_x, menu_y, menu_width, menu_height, button_width, button_height;
```

```
Position button_x, button_y;
```

```
temp = XtParent(w); /* Shell not menu entry is parent of menu */
```

```
while(temp != NULL) {
```

```
    menu = XtNameToWidget(temp, mbw->sme_bsb.menu_name);
```

```
    if (menu == NULL)
```

```
        temp = XtParent(temp);
```

```
    else
```

```
        break;
```

```
}
```

```
if (menu == NULL) {
```

```
    char error_buf[BUFSIZ];
```

```
    sprintf(error_buf, "MenuButton: %s %s.",
```

```
            "Could not find menu widget named", mbw->sme_bsb.menu_name);
```

```
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
```

```
    return;
```

```
}
```

```
if (!XtIsRealized(menu))
```

```
    XtRealizeWidget(menu);
```

```
menu_width = menu->core.width + 2 * menu->core.border_width;
```

```
button_width = w->core.width + 2 * w->core.border_width;
```

```
button_height = w->core.height + 2 * w->core.border_width;
```

```
menu_height = menu->core.height + 2 * menu->core.border_width;
```

```
XtTranslateCoords(w, 0, 0, &button_x, &button_y);
```

```
menu_x = button_x + button_width;
```

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```
menu_y = bunon_y;
```

```
if (menu_x < 0)
```

```
    menu_x = 0;
```

```
else {
```

```
    int scr_width = WidthOfScreen(XtScreen(menu));
```

```
    if (menu_x + menu_width > scr_width)
```

```
        menu_x = scr_width - menu_width;
```

```
}
```

```
if (menu_y < 0)
```

```
    menu_y = 0;
```

```
else {
```

```
    int scr_height = HeightOfScreen(XtScreen(menu));
```

```
    if (menu_y + menu_height > scr_height)
```

```
        menu_y = scr_height - menu_height;
```

```
}
```

```
num_args = 0;
```

```
XtSetArg(arglist[num_args], XtNx, menu_x); num_args++;
```

```
XtSetArg(arglist[num_args], XtNy, menu_y); num_args++;
```

```
XtSetValues(menu, arglist, num_args);
```

```
XtPopupSpringLoaded(menu);
```

```
}
```

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## source/Storage.c

```
/*
    Routines to allow video frames to be stored in memory
    or on disk: NewFrame, GetFrame, SaveFrame, FreeFrame, SaveHeader,
    CopyHeader.
*/

#include    "../include/xwave.h"
extern FILE *zopen();
extern void zseek();
extern void zclose();

void NewFrame(vid,number)

Video vid;
int    number;

{
    if (vid->data[0][number]==NULL) {
        int    channel, channels=vid->type==MONO?1:3;

        for(channel=0;channel<channels;channel++)
            vid->data[channel][number]=(short
*)MALLOC(sizeof(short)*Size(vid,channel,0)*Size(vid,channel,1));
    }
}

void GetFrame(vid,number)

Video vid;
```

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```

int    number;

{
    if (vid->data[0][number] == NULL) {
        char    file_name[STRLEN], *whole_frame;
        FILE    *fp, *fopen();
        int     pid, r, c, channel,
                start = vid->x_offset + vid->cols*vid->y_offset,

end = (vid->rows-vid->y_offset-vid->size[1])*vid->cols-vid->x_offset,
        inter = vid->cols-vid->size[0];

        NewFrame(vid,number);

        sprintf(file_name, "%s%s/%s/%s%03d\0", global->home, IMAGE_DIR, vid->path, vid->files[0] == '\0'?vid->name:vid->files,number+vid->start);
        Dprintf("Reading file %s\n",file_name);
        fp = zopen(file_name,&pid);
        if (vid->precision == 0) whole_frame = (char
*)MALLOC(vid->rows*vid->cols);
        zseek(fp,vid->offset);
        for(channel=0;channel<(vid->type == MONO?1:3);channel++) {
            int    shift[2] = {vid->type == YUV &&
channel!=0?vid->UVsample[0]:0,vid->type == YUV &&
channel!=0?vid->UVsample[1]:0};

            Dprintf("Reading channel %d\n",channel);
            if (vid->precision == 0) {

if(0 == fread(whole_frame,sizeof(char),(vid->cols>>shift[0])*(vid->rows>>shift[1]),
fp)) {

                Dprintf("Error whilst reading %s\n",file_name);

```

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```

        Eprintf("Error whilst reading %s\n",file_name);
    }
    for(r=0;r<vid->size[1]>>shift[1];r++)
        for(c=0;c<vid->size[0]>>shift[0];c++) {
            short
pel=cti(whole_frame[(vid->x_offset>>shift[0])+c+((vid->y_offset>>shift[1])+r)*(
vid->cols>>shift[0])));

vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=vid->negative?-1-pel:pel;
    }
    } else {
        if (start!=0) zseek(fp,start*sizeof(short));
        for(r=0;r<vid->size[1]>>shift[1];r++) {

if(0==fread(&(vid->data[channel][number][r*(vid->size[0]>>shift[0])]),sizeof(short),
vid->size[0]>>shift[0],fp)) {

            Dprintf("Error whilst reading

%s\n",file_name);

            Eprintf("Error whilst reading

%s\n",file_name);

        }
        if (inter!=0) zseek(fp,inter*sizeof(short));
        if (vid->negative)
            for(c=0;c<vid->size[0]>>shift[0];c++)

vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=-1-vid->data[channel][nu
mber][c+r*(vid->size[0]>>shift[0])];

```



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## source/Storage.c

/\*

Routines to allow video frames to be stored in memory

or on disk: NewFrame, GetFrame, SaveFrame, FreeFrame, SaveHeader,

CopyHeader.

\*/

#include "../include/xwave.h"

extern FILE \*zopen();

extern void zseek();

extern void zclose();

void NewFrame(vid,number)

Video vid;

int number;

{

if (vid-&gt;data[0][number] == NULL) {

int channel, channels=vid-&gt;type == MONO?1:3;

for(channel=0;channel &lt; channels;channel++)

vid-&gt;data[channel][number] = (short

\*)MALLOC(sizeof(short)\*Size(vid,channel,0)\*Size(vid,channel,1));

}

}

void GetFrame(vid,number)

Video vid;

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```

int    number;

{
    if (vid->data[0][number] == NULL) {
        char    file_name[STRLEN], *whole_frame;
        FILE    *fp, *fopen();
        int     pid, r, c, channel,
                start = vid->x_offset + vid->cols*vid->y_offset,

end = (vid->rows - vid->y_offset - vid->size[1])*vid->cols - vid->x_offset,
        inter = vid->cols - vid->size[0];

        NewFrame(vid, number);

        sprintf(file_name, "%s%s/%s/%s%03d\0", global->home, IMAGE_DIR, vid->path, vid->files[0] == '\0'?vid->name:vid->files, number + vid->start);
        Dprintf("Reading file %s\n", file_name);
        fp = zreopen(file_name, &pid);
        if (vid->precision == 0) whole_frame = (char
*)MALLOC(vid->rows*vid->cols);
        zseek(fp, vid->offset);
        for(channel = 0; channel < (vid->type == MONO?1:3); channel++) {
            int    shift[2] = {vid->type == YUV &&
channel != 0?vid->UVsample[0]:0, vid->type == YUV &&
channel != 0?vid->UVsample[1]:0};

            Dprintf("Reading channel %d\n", channel);
            if (vid->precision == 0) {

if(0 == fread(whole_frame, sizeof(char), (vid->cols >> shift[0])*(vid->rows >> shift[1]),
fp)) {

                Dprintf("Error whilst reading %s\n", file_name);

```

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```

        Eprintf("Error whilst reading %s\n",file_name);
    }
    for(r=0;r < vid-> size[1] > > shift[1];r++)
        for(c=0;c < vid-> size[0] > > shift[0];c++) {
            short
pel=cti(whole_frame[(vid-> x_offset > > shift[0])+c+((vid-> y_offset > > shift[1])+r)*(
vid-> cols > > shift[0])));

vid-> data[channel][number][c+r*(vid-> size[0] > > shift[0])] = vid-> negative?-1-pel:pel;
        }
    } else {
        if (start!=0) zseek(fp,start*sizeof(short));
        for(r=0;r < vid-> size[1] > > shift[1];r++) {

if(0==fread(&(vid-> data[channel][number][r*(vid-> size[0] > > shift[0]))),sizeof(short),
vid-> size[0] > > shift[0],fp)) {

            Dprintf("Error whilst reading

%s\n",file_name);

            Eprintf("Error whilst reading

%s\n",file_name);

        }
        if (inter!=0) zseek(fp,inter*sizeof(short));
        if (vid-> negative)
            for(c=0;c < vid-> size[0] > > shift[0];c++)

vid-> data[channel][number][c+r*(vid-> size[0] > > shift[0])] = -1-vid-> data[channel][nu
mber][c+r*(vid-> size[0] > > shift[0])];

```

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}

```
void SaveHeader(vid)
```

```
Video vid;
```

{

```
FILE *fp, *fopen();
```

```
char file_name[STRLEN];
```

```
String types[] = {"MONO", "RGB", "YUV"};
```

```
Dprintf("SaveHeader %s\n", vid->name);
```

```
sprintf(file_name, "%s%s/%s%s\0", global->home, VID_DIR, vid->name, VID_EXT);
```

```
fp = fopen(file_name, "w");
```

```
fprintf(fp, "Path \" %s\" \n", vid->path);
```

```
if (vid->files[0] != '\0') fprintf(fp, "Files \" %s\" \n", vid->files);
```

```
if (vid->type == YUV) fprintf(fp, "Type %s %d
```

```
%d\n", types[vid->type], vid->UVsample[0], vid->UVsample[1]);
```

```
else fprintf(fp, "Type %s\n", types[vid->type]);
```

```
if (vid->rate != 0) fprintf(fp, "Rate %d\n", vid->rate);
```

```
if (vid->disk) fprintf(fp, "Disk\n");
```

```
if (vid->gamma) fprintf(fp, "Gamma\n");
```

```
fprintf(fp, "Start %03d\n", vid->start);
```

```
fprintf(fp, "Length %d\n", vid->size[2]);
```

```
fprintf(fp, "Dimensions %d %d\n", vid->cols, vid->rows);
```

```
switch(vid->trans.type) {
```

```
case TRANS_None: fprintf(fp, "Transform None\n"); break;
```

```
case TRANS_Wave: fprintf(fp, "Transform Wavelet %d %d
```

```
%s\n", vid->trans.wavelet.space[0], vid->trans.wavelet.space[1], vid->trans.wavelet.dirn
```

```
? "Yes": "No"); break;
```

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```

    }
    fprintf(fp, "Header %d\n", vid->offset);
    fprintf(fp, "Offsets %d %d\n", vid->x_offset, vid->y_offset);
    fprintf(fp, "Size %d %d\n", vid->size[0], vid->size[1]);
    fprintf(fp, "Precision %d\n", vid->precision);
    fclose(fp);
}

```

Video CopyHeader(src)

Video src;

```

{
    Video dst=(Video)MALLOC(sizeof(VideoRec));
    int    channel;

    Dprintf("CopyHeader %s\n",src);
    strcpy(dst->path,src->path);
    strcpy(dst->name,src->name);
    dst->type = src->type;
    dst->disk = src->disk;
    dst->gamma = src->gamma;
    dst->negative = False;
    dst->rate = src->rate;
    dst->start = src->start;
    dst->size[0] = src->size[0];
    dst->size[1] = src->size[1];
    dst->size[2] = src->size[2];
    dst->UVsample[0] = src->UVsample[0];
    dst->UVsample[1] = src->UVsample[1];
    dst->offset = 0;
    dst->cols = src->size[0];
}

```

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```
dst->rows = src->size[1];
dst->x_offset = 0;
dst->y_offset = 0;
dst->trans = src->trans;
dst->precision = src->precision;
for(channel=0;channel < (src->type == MONO?1:3);channel++)
    dst->data[channel] = (short **)MALLOC(src->size[2]*sizeof(short *));
return(dst);
}
```

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## source/Transform.c

```
/*
    Transform video using wavelet transform
*/

#include    "xwave.h"
#include    "Transform.h"
extern short Round();

void DropVideo(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    Video video=global->videos->next;
    int    frame, channel;

    for(channel=0;channel<(global->videos->type==MONO?1:(global->videos->type==YUV?3:4));channel++)
        if (global->videos->data[channel]!=NULL) {
            for (frame=0;frame<global->videos->size[2];frame++)
                if (global->videos->data[channel][frame]!=NULL)
                    XtFree(global->videos->data[channel][frame]);
            XtFree(global->videos->data[channel]);
        }
    XtFree(global->videos);
    global->videos=video;
}
```

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}

```
void ChangePrecision(src,dst,frame,old,new)
```

```
Video src, dst;
```

```
int frame, old, new;
```

{

```
int channel, i;
```

```
if(src!=dst || old!=new) {
```

```
int shift=new-old;
```

```
Dprintf("Changing precision %d to %d for frame %d\n",old,new,frame);
```

```
for (channel=0;channel<(src->type==MONO?1:3);channel++) {
```

```
int size=Size(src,channel,0)*Size(src,channel,1);
```

```
for(i=0;i<size;i++)
```

```
dst->data[channel][frame][i]=shift<0?Round(src->data[channel][frame][i],-shift):(shift
==0?src->data[channel][frame][i]:src->data[channel][frame][i]<<shift);
```

```
}
```

```
}
```

}

```
void TransformCtrl(w,closure,call_data)
```

```
Widget w;
```

```
caddr_t closure, call_data;
```

{

```
TransCtrl ctrl=(TransCtrl)closure;
```



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```

Video src = ctrl->src, dst = CopyHeader(src);
long i, frame, channel;

Dprintf("TransformCtrl\n");
strcpy(dst->name, ctrl->name);
dst->trans.type = TRANS_Wave;
dst->trans.wavelet.space[0] = ctrl->space[0];
dst->trans.wavelet.space[1] = ctrl->space[1];
dst->trans.wavelet.dirn = ctrl->dirn;
dst->precision = ctrl->precision;
strcpy(dst->files, dst->name);
if (dst->disk) SaveHeader(dst);
if (src->trans.type != TRANS_Wave) {
    src->trans.type = TRANS_Wave;
    src->trans.wavelet.space[0] = 0;
    src->trans.wavelet.space[1] = 0;
}

if (src->trans.wavelet.space[0] != dst->trans.wavelet.space[0] ||
src->trans.wavelet.space[1] != dst->trans.wavelet.space[1])
    for(frame = 0; frame < dst->size[2]; frame++) {
        int
max_precision = src->precision > dst->precision ? src->precision : dst->precision;

        Dprintf("Processing frame %d\n", frame);
        NewFrame(dst, frame);
        GetFrame(src, frame);
        ChangePrecision(src, dst, frame, src->precision, max_precision);
        for (channel = 0; channel < (src->type == MONO ? 1 : 3); channel++)
        {
            int oct_src = src->trans.wavelet.space[channel == 0 ? 0 : 1],

```

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```
oct_dst = dst->trans.wavelet.space[channel == 0?0:1],
```

```
size[2] = {Size(dst,channel,0),Size(dst,channel,1)};
```

```
if (oct_src != oct_dst)
```

```
Convoive(dst->data[channel][frame],curl->dim.size,oct_src,oct_dst):
```

```
}
```

```
ChangePrecision(dst,dst,frame,max_precision,dst->precision);
```

```
SaveFrame(dst,frame);
```

```
FreeFrame(dst,frame);
```

```
FreeFrame(src,frame);
```

```
}
```

```
if (src->trans.wavelet.space[0] == 0 && src->trans.wavelet.space[1] == 0)
```

```
src->trans.type = TRANS_None;
```

```
if (dst->trans.wavelet.space[0] == 0 && dst->trans.wavelet.space[1] == 0) {
```

```
dst->trans.type = TRANS_None;
```

```
if (dst->disk) SaveHeader(dst);
```

```
}
```

```
dst->next = global->videos;
```

```
global->videos = dst;
```

```
}
```

```
void Transype(w,closure,call_data)
```

```
Widget w;
```

```
caddr_t closure, call_data;
```

```
{
```

```
Video vid=(Video)closure;
```

```
if (vid->trans.wavelet.space[0] == 0 && vid->trans.wavelet.space[1] == 0)
```

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```
vid->trans.type = TRANS_None;
```

```
}
```

```
void BatchTransCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
```

```
    TransCtrl    ctrl=(TransCtrl)closure;
```

```
    if (ctrl->src == NULL) ctrl->src = FindVideo(ctrl->src_name,global->videos);
```

```
    if (ctrl->src->trans.type == TRANS_Wave)
```

```
ctrl->dim=ctrl->src->trans.wavelet.dim;
```

```
    TransformCtrl(w,closure,call_data);
```

```
}
```

```
TransCtrl    InitTransCtrl(name)
```

```
String name;
```

```
{
```

```
    TransCtrl    ctrl=(TransCtrl)MALLOC(sizeof(TransCtrlRec));
```

```
    strcpy(ctrl->src_name,name);
```

```
    strcpy(ctrl->name,name);
```

```
    ctrl->dim=False;
```

```
    Dprintf("Transform\n");
```

```
    return(ctrl);
```

```
}
```

```
#define      TRANS_ICONS      16
```

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```

void Transform(w.closure.call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Video video=(Video)closure;
    TransCtrl ctrl=InitTransCtrl(video->name);
    NumInput spaceInput=(NumInput)MALLOC(2*sizeof(NumInputRec)),
        precInput=(NumInput)MALLOC(sizeof(NumInputRec));
    Message msg=NewMessage(ctrl->name,NAME_LEN);
    XtCallbackRec destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)spaceInput},
        {Free,(caddr_t)precInput},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Widget parent=FindWidget("frm_transform",XtParent(w)),

shell=ShellWidget("transform",parent,SW_below,NULL,destroy_call),
    form=FormatWidget("trans_form",shell),
widgets[TRANS_ICONS];
    FormItem items[]={
        {"trans_cancel","cancel",0,0,FW_icon,NULL},
        {"trans_confirm","confirm",1,0,FW_icon,NULL},
        {"trans_title","Transform a video",2,0,FW_label,NULL},
        {"trans_vid_lab","Video Name:",0,3,FW_label,NULL},
        {"trans_video",NULL,4,3,FW_text,(String)msg},

        {"trans_dirn_lab","Direction:",0,4,FW_label,NULL},
        {"trans_dirn".NULL,4,4,FW_yn,(String)&ctrl->dirn},
    }
}

```

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```

{"trans_bits_int",NULL,0,6,FW_integer,(String)precInput},
{"trans_bits_down",NULL,4,6,FW_down,(String)precInput},
{"trans_bits_up",NULL,9,6,FW_up,(String)precInput},

{"trans_spc0_int",NULL,0,8,FW_integer,(String)&spaceInput[0]},
{"trans_spc0_down",NULL,4,8,FW_down,(String)&spaceInput[0]},
{"trans_spc0_up",NULL,12,8,FW_up,(String)&spaceInput[0]},
{"trans_spc1_int",NULL,0,11,FW_integer,(String)&spaceInput[1]},
{"trans_spc1_down",NULL,4,11,FW_down,(String)&spaceInput[1]},

{"trans_spc1_up",NULL,15,11,FW_up,(String)&spaceInput[1]},

};

XtCallbackRec      callbacks[] = {
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {TransformCtrl,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->dirn}, {NULL,NULL},
    {NumIncDec,(caddr_t)precInput}, {NULL,NULL},
    {NumIncDec,(caddr_t)precInput}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[1]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[1]}, {NULL,NULL},
};

Dprintf("Transform\n");
msg->rows=1; msg->cols=NAME_LEN;
ctrl->src=video;
if (video->trans.type==TRANS_Wave) {
    ctrl->space[0]=video->trans.wavelet.space[0];

```

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```
    ctrl->space[1]=video->trans.wavelet.space[1];
    ctrl->dirn=video->trans.wavelet.dirn;
} else {
    ctrl->space[0]=0; ctrl->space[1]=0;
    ctrl->dirn=False;
}
ctrl->precision=video->precision;

spaceInput[0].format=video->type==YUV?"Y-Space: %d":"Space: %d";
spaceInput[0].max=100;
spaceInput[0].min=0;
spaceInput[0].value=&ctrl->space[0];
if (video->type==YUV) {
    spaceInput[1].format="UV-Space: %d";
    spaceInput[1].max=100;
    spaceInput[1].min=0;
    spaceInput[1].value=&ctrl->space[1];
}
preInput->format="Precision: %d";
preInput->max=16;
preInput->min=0;
preInput->value=&ctrl->precision;
```

```
FillForm(form,TRANS_ICONS-(video->type==YUV?0:3),items,widgets,callbacks);
if (video->trans.type==TRANS_Wave) XtSetSensitive(widgets[6],False);
XtPopup(shell,XtGrabExclusive);
}
```

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## source/Update.c

```
/*  
    Update Image, Info and InfoText from positional information  
*/
```

```
#include    "../include/xwave.h"  
#include    <varargs.h>  
extern int  CompositePixel();  
extern int  Dither();  
extern short Round();  
extern int  ReMap();  
extern Palette FindPalette();  
  
char  *ResizeData(size)  
  
int    size;  
  
{  
    static char    *data=NULL;  
    static int      data_size=0;  
  
    if (size!=data_size) {  
        Dprintf("New frame memory\n");  
        if (data!=NULL) XtFree(data);  
        data=(char *)MALLOC(size);  
        data_size=size;  
    }  
    return(data);  
}
```

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Pixmap      UpdateImage(frame)

Frame frame;

```
{
    int    x, y, i;
    Display      *dpy = XtDisplay(global->toplevel);
    void    CvtIndex(), UpdatePoint();
    Palette      pal = FindPalette(global->palettes, frame->palette);
    Video vid = frame->video;
    int    scrn = XDefaultScreen(dpy), depth = DisplayPlanes(dpy, scrn),
           size[2] = {Size(vid, frame->channel, 0), Size(vid, frame->channel, 1)},
           img_size[2] = {size[0] << frame->zoom, size[1] << frame->zoom},
           bpl = (img_size[0]*depth+7)/8, new_size = img_size[1]*bpl,
           space = vid->trans.wavelet.space[vid->type == YUV &&
frame->channel != 0 && frame->channel != 3?1:0];
    char    *data = ResizeData(new_size);
    XImage
    *image = XCreateImage(dpy, global->visinfo->visual, depth, ZPixmap, 0, data, img_size[0], i
mg_size[1], 8, bpl);
    Pixmap
    pixmap = XCreatePixmap(dpy, DefaultRootWindow(dpy), img_size[0], img_size[1], depth);

    Dprintf("UpdateImage\n");
    if (global->levels == 2 && frame->channel == 3) frame->channel = 0;
    for(y=0; y < size[1]; y++) for(x=0; x < size[0]; x++) {
        int    data_x = x, data_y = y, off_x, off_y, oct;

        if (vid->trans.type == TRANS_Wave)
CvtIndex(x, y, size[0], size[1], space, &data_x, &data_y, &oct);
        for(off_x=0; off_x < 1 << frame->zoom; off_x++)
            for(off_y=0; off_y < 1 << frame->zoom; off_y++) {
```



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```

        int    img_x = off_x + (x < < frame-> zoom),
img_y = off_y + (y < < frame-> zoom),

pix = CompositePixel(frame, data_x, data_y, img_x, img_y);

XPutPixel(image, img_x, img_y, RMap(pix, global-> levels, pal));
    }
}

XPutImage(dpy, pixmap, DefaultGC(dpy, scrn), image, 0, 0, 0, 0, img_size[0], img_size[1]);
    if (frame-> point_switch == True) UpdatePoint(dpy, frame, pixmap);
    XtFree(image);
    return(pixmap);
}

void  CvIndex(x, y, max_x, max_y, oct, ret_x, ret_y, ret_oct)

int    x, y, max_x, max_y, oct, *ret_x, *ret_y, *ret_oct;

{
    Boolean    hgx = x >= (max_x >> 1), hgy = y >= (max_y >> 1);

    *ret_x = hgx ? x - (max_x >> 1) : x;
    *ret_y = hgy ? y - (max_y >> 1) : y;
    if (!hgx && !hgy && oct > 1) {

CvIndex(*ret_x, *ret_y, max_x >> 1, max_y >> 1, oct-1, ret_x, ret_y, ret_oct);
        *ret_x = *ret_x << 1;
        *ret_y = *ret_y << 1;
        *ret_oct += 1;
    } else {

```

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```

        *ret_x = (*ret_x < 1) + hgx;
        *ret_y = (*ret_y < 1) + hgy;
        *ret_oct = hgx || hgy ? 0 : 1;
    }
}

void UpdateInfo(frame)

Frame frame;

{
    Message    msg = frame->msg;
    Video vid = frame->video;
    int    *locn = frame->point->location, posn[2] = {locn[0], locn[1]},
           channel = 3 == frame->channel ? 0 : frame->channel,
width = Size(vid, channel, 0);
    short    *data = vid->data[channel][frame->frame];

    msg->info.ptr[0] = '\0';
    msg->info.length = 0;
    if (vid->type == YUV && channel != 0) {
        posn[0] = posn[0] >> vid->UVsample[0];
        posn[1] = posn[1] >> vid->UVsample[1];
    }
    if (vid->trans.type != TRANS_Wave)
        Mprintf(msg, "Point   : x = %03d y = %03d t = %03d
c = %4d", locn[0], locn[1], frame->frame + vid->start, data[posn[0] + Size(vid, channel, 0) * po
sn[1]]);
    else {
        int    octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0 ? 1 : 0],
X, Y, oct, sub,

```

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```
blkDC[2] = {(posn[0] > > octs)&-2, (posn[1] > > octs)&-2},
```

```
offDC[2] = {(posn[0] > > octs)&1, (posn[1] > > octs)&1};
```

```
Mprintf(msg, "Point : f= %03d x= %03d
```

```
y= %03d\n", frame->frame + vid->start, locn[0], locn[1]);
```

```
Mprintf(msg, "Low pass: x= %03d y= %03d\n", blkDC[0], blkDC[1]);
```

```
for(Y=0; Y<2; Y++) {
```

```
    for(X=0; X<2; X++)
```

```
Mprintf(msg, " %4d%c", data[Access(blkDC[0]+X, blkDC[1]+Y, octs-1, 0, width)], X == off
```

```
DC[0] && Y == offDC[1]? '*' : ' ');
```

```
    Mprintf(msg, "\n");
```

```
}
```

```
for(oct=octs; oct>0; oct--) {
```

```
    int blk[2] = {(posn[0] > > oct)&-2, (posn[1] > > oct)&-2},
```

```
    off[2] = {(posn[0] > > oct)&1, (posn[1] > > oct)&1};
```

```
Mprintf(msg, "Oct : %d\n", oct);
```

```
for(Y=0; Y<2; Y++) {
```

```
    for(sub=1; sub<4; sub++) {
```

```
        for(X=0; X<2; X++) {
```

```
Mprintf(msg, " %4d%c", data[Access(blk[0]+X, blk[1]+Y, oct-1, sub, width)], X == off[0]
```

```
&& Y == off[1]? '*' : ' ');
```

```
        }
```

```
        if (sub<3) Mprintf(msg, " ");
```

```
    }
```

```
    if (oct!=0 || Y==0) Mprintf(msg, "\n");
```

```
}
```

```
}
```

```
}
```

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```

    Mflush(msg);
}

/*  Function Name:    CrossHair.
 *  Description:    Draws cross-hair on pixmap
 *  Arguments:    dpy - Xserver display
 *                pixmap - pixmap to draw on
 *                gc - GC to draw with
 *                x_off, y_off - offset into pixmap
 *                width, height - size of box containing cross-hair
 *                x, y - coordinates within box
 *                zoom - scaling factor
 *  Returns:    alters pixmap.
 */

```

```
void CrossHair(dpy,pixmap,gc,x_off,y_off,width,height,x,y,zoom)
```

```

Display    *dpy;
Pixmap     pixmap;
GC         gc;
int        x_off, y_off, width, height, x, y, zoom;

```

```

{
    int    xtra = Shift(1,zoom);

    x_off = Shift(x_off,zoom);
    y_off = Shift(y_off,zoom);
    width = Shift(width,zoom);
    height = Shift(height,zoom);
    x = Shift(x,zoom);
    y = Shift(y,zoom);

```

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```

XFillRectangle(dpy,pixmap,gc,x+x_off+extra/2,y_off,1,y); /* North hair */
XFillRectangle(dpy,pixmap,gc,x_off,y+y_off+extra/2,x,1); /* West hair */
XFillRectangle(dpy,pixmap,gc,x+x_off+extra/2,y+y_off+extra,1,height-y-extra); /*
South hair */
XFillRectangle(dpy,pixmap,gc,x+x_off+extra,y+y_off+extra/2,width-x-1,1); /*
East hair */
}

```

```

/*  Function Name:      UpdatePoint
 *  Description:  Draws cross-hair on image at frame->location
 *  Arguments:   dpy - X server display
 *               frame - Frame supplying drawing parameters
 *               pixmap - X pixmap to draw on
 *  Returns:      alters pixmap.
 */

```

```
void  UpdatePoint(dpy,frame,pixmap)
```

```
Display      *dpy;
```

```
Frame frame;
```

```
Pixmap      pixmap;
```

```

{
    unsigned long      gcmask;
    XGCValues  gcvals;
    GC  gc;
    Video vid=frame->video;
    int  posn[2]={frame->point->location[0],frame->point->location[1]},
channel=3==frame->channel?0:frame->channel;

    gcvals.function=GXequiv;
    gcmask=GCFFunction;

```

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```

gcvals.foreground = 127;
gcmask = gcmask | GCForeground;
gc = XCreateGC(dpy, pixmap, gcmask, &gcvals);
if (vid->type == YUV && channel != 0) {
    posn[0] = posn[0] >> vid->UVsample[0];
    posn[1] = posn[1] >> vid->UVsample[1];
}
if (vid->trans.type != TRANS_Wave) {

CrossHair(dpy, pixmap, gc, 0, 0, Size(vid, channel, 0), Size(vid, channel, 1), posn[0], posn[1], fra
me->zoom);
    } else {
        int    octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0 ? 1 : 0], oct,
                size[2] = {Size(vid, channel, 0), Size(vid, channel, 1)};

CrossHair(dpy, pixmap, gc, 0, 0, size[0], size[1], posn[0], posn[1], frame->zoom-octs);
        for(oct = 1; oct <= octs; oct++) {

CrossHair(dpy, pixmap, gc, size[0], 0, size[0], size[1], posn[0], posn[1], frame->zoom-oct);

CrossHair(dpy, pixmap, gc, 0, size[1], size[0], size[1], posn[0], posn[1], frame->zoom-oct);

CrossHair(dpy, pixmap, gc, size[0], size[1], size[0], size[1], posn[0], posn[1], frame->zoom-oct
);
        }
    }
XFreeGC(dpy, gc);
}

```

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source/Video2.c

```
/*
    Video callback routines for Listing, Loading
*/

#include    "../include/xwave.h"
#include    "../include/ImageHeader.h"
#include    "../include/DTheader.h"
#include    "Video.h"
#include    <sys/time.h>
extern void EraseFrame();
extern void CvtIndex();

void SortList(list,no)

String list[];
int    no;

{
    int    i, j, k;

    if (no > 1) for(i=1;i < no;i++) for(j=0;j < i;j++) {
        k=0;
        while(list[i][k] == list[j][k] && list[i][k] != '\0' && list[j][k] != '\0') k++;
        if (list[i][k] < list[j][k]) {
            String spare = list[i];

            list[i] = list[j];
            list[j] = spare;
        }
    }
}
```

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```

    }
}

String *ReadDirectory(dir_path.extension)

String dir_path.extension;

{
    DIR *dirp, *opendir();
    struct dirent *dp, *readdir();
    static String *fileList=NULL, file;
    int count=0, i;
    char path[STRLEN];

    Dprintf("ReadDirectory for %s extension\n",extension);
    if (fileList!=NULL) {
        for(i=0;NULL!=fileList[i];i++) free(fileList[i]);
        free(fileList);
    }
    fileList=(String *)MALLOC(sizeof(String *)*300);
    sprintf(path,"%s%s\0",global->home,dir_path);
    dirp=opendir(path);
    for (dp=readdir(dirp);dp!=NULL && count<299;dp=readdir(dirp)) {
        int length=strlen(dp->d_name);

        if (length>=strlen(extension))
            if (!strcmp(dp->d_name+length-strlen(extension),extension)) {
                Dprintf("Found %s in dir\n",dp->d_name);
                fileList[count]=(char *)MALLOC(length+1);
                strcpy(fileList[count],dp->d_name,length-strlen(extension));
                count+=1;
            }
    }
}

```



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```

    }
    fileList[count] = NULL;
    SortList(fileList, count);
    closedir(dirp);
    return(fileList);
}

```

```

int  Shift(value, shift)

```

```

int  value, shift;

```

```

{
    if (shift == 0) return value;
    else if (shift < 0) return(value >> -shift);
    else return(value << shift);
}

```

```

int  Size(video, channel, dimension)

```

```

Video video;

```

```

int  channel, dimension;

```

```

{
    if (video->type == YUV && dimension != 2 && channel != 0 && channel != 3)
return(video->size[dimension] >> video->UVsample[dimension]);
    else return(video->size[dimension]);
}

```

```

int  Address2(video, channel, x, y)

```

```

Video video;

```

```

int  channel, x, y;

```

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```
{
    if (video->type == YUV && channel!=0 && channel!=3)
return(x + Size(video,channel,0)*y);
    else return(x + video->size[0]*y);
}

int    Address(video,channel,x,y)

Video video;
int    channel, x, y;

{
    if (video->type == YUV && channel!=0 && channel!=3)
return((x >> video->UVsample[0]) + Size(video,channel,0)*(y >> video->UVsample[1])
);
    else return(x + video->size[0]*y);
}

String *VideoList()

{
    Dprintf("VideoList\n");
    return(ReadDirectory(VID_DIR,VID_EXT));
}

String *KlicsList()

{
    Dprintf("KlicsList\n");
    return(ReadDirectory(KLICS_DIR,KLICS_EXT));
}
```

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String \*KlicsListSA()

```
{
    Dprintf("KlicsListSA\n");
    return(ReadDirectory(KLICS_SA_DIR,KLICS_SA_EXT));
}
```

String \*VideoCurrentList()

```
{
    static String videoList[300];
    Video video=global->videos;
    int count=0;

    Dprintf("VideoCurrentList\n");
    while (video!=NULL) {
        if (count==300) Dprintf("VideoCurrentList: static size exceeded\n");
        videoList[count]=video->name;
        video=video->next;
        count+=1;
    }
    videoList[count]=NULL;
    SortList(videoList,count);
    return(videoList);
}
```

String \*VideoYUVList()

```
{
    static String videoList[300];
    Video video=global->videos;
    int count=0;
```

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```

Dprintf("VideoCurrentList\n");
while (video != NULL) {
    if (count == 300) Dprintf("VideoYUVList: static size exceeded\n");
    if (video->type == YUV) videoList[count++] = video->name;
    video = video->next;
}
videoList[count] = NULL;
SortList(videoList, count);
return(videoList);
}

```

```
String *VideoDropList()
```

```

{
    static String videoList[300];
    Video video = global->videos;
    int count = 0;
    Boolean VideoHasFrame();

    Dprintf("VideoDropList\n");
    while (video != NULL) {
        if (False == VideoHasFrame(video, global->frames)) {
            videoList[count] = video->name;
            count++;
        };
        video = video->next;
    }
    videoList[count] = NULL;
    SortList(videoList, count);
    return(videoList);
}

```

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```
Boolean    VideoHasFrame(video.frame)
```

```
Video video;
```

```
Frame frame;
```

```
{
    if (frame == NULL) return(False);
    else if (frame->video == video) return(True);
        else return(VideoHasFrame(video,frame->next));
}
```

```
void    VideoLoad(w,closure,call_data)
```

```
Widget    w;
```

```
caddr_t    closure, call_data;
```

```
{
    Video vid=(Video)MALLOC(sizeof(VideoRec));
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    int    frame, channel;

    Dprintf("VideoLoad %s\n",name->string);
    strcpy(vid->name,name->string);
    strcpy(vid->files,name->string);
    vid->next=global->videos;
    global->videos=vid;
    vid->rate=30;
    Parse(VID_DIR,name->string,VID_EXT);
    for (channel=0;channel<(vid->type==MONO?1:3);channel++)
        vid->data[channel]=(short **)MALLOC(sizeof(short *)*vid->size[2]);
    if (!vid->disk) for(frame=0;frame<vid->size[2];frame++)
        GetFrame(vid.frame);
}
```

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```

    Dprintf("VideoLoad terminated\n");
    if (global->batch == NULL) InitFrame(w.closure.call_data);
}

void VideoSave(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Video video;
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    int      frame;

    video=FindVideo(name->string,global->videos);
    if (video->files[0] == '\0') strcpy(video->files,name->string);
    SaveHeader(video);
    for (frame=0;frame < video->size[2];frame++) {
        Boolean      disk=video->disk;

        GetFrame(video,frame);
        video->disk=True;
        SaveFrame(video,frame);
        video->disk=disk;
        FreeFrame(video,frame);
    }
    Dprintf("VideoSave terminated\n");
}

void VideoDTSave(w,closure,call_data)

Widget      w;

```

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```
caddr_t      closure, call_data;
```

```
{
```

```
    Video video;
```

```
    FILE *fp, *fopen();
```

```
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
    char  file_name[STRLEN], whole_frame[512][512];
```

```
    int   frame, i, x, y, offset[2];
```

```
    DTheader
```

```
header={ "DT-IMAGE",1,4,1,2,"",1,{0,0,4,0},1,1,0,1,{4,3},8,1,{0,2},{0,2},{0,2},{0,2}, "", "xwave generated image", ""};
```

```
    Dprintf("VideoDTSave %s\n",name->string);
```

```
    video=FindVideo(name->string,global->videos);
```

```
    sprintf(file_name,"%s%s/%s/%s%s\0",global->home,IMAGE_DIR,video->path,video->files,".img");
```

```
    offset[0]=(512-video->size[0])/2;
```

```
    offset[1]=(512-video->size[1])/2;
```

```
    offset[0]=offset[0]<0?0:offset[0];
```

```
    offset[1]=offset[1]<0?0:offset[1];
```

```
    fp=fopen(file_name,"w");
```

```
    fwrite(&header,1,sizeof(DTheader),fp);
```

```
    GetFrame(video,0);
```

```
    for(y=0;y<512;y++) for(x=0;x<512;x++) {
```

```
        int   X, Y, oct;
```

```
        if (y<offset[1] || x<offset[0] || y-offset[1]>=video->size[1] ||
```

```
        x-offset[0]>=video->size[0]) whole_frame[y][x]=0;
```

```
        else {
```

```
            if (video->trans.type==TRANS_Wave) {
```

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```
CvIndex(x-offset[0],y-offset[1],video->size[0],video->size[1],video->trans.wavelet.space[0],&X,&Y,&oct);
```

```
whole_frame[y][x]=128+Round(video->data[0][0][Y*video->size[0]+X]*(oct==video->trans.wavelet.space[0]?1:4),video->precision);
```

```
    } else {
```

```
        X=x-offset[0]; Y=y-offset[1];
```

```
whole_frame[y][x]=128+Round(video->data[0][0][Y*video->size[0]+X],video->precision);
```

```
    }
```

```
  }
```

```
}
```

```
FreeFrame(video,0);
```

```
fwrite(whole_frame,1,512*512,fp);
```

```
fclose(fp);
```

```
}
```

```
void VideoXimSave(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Video video;
```

```
    FILE *fp, *fopen();
```

```
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
    char file_name[STRLEN], *whole_frame;
```

```
    int frame, channel, i, x, y;
```

```
    ImageHeader header;
```

```
Dprintf("VideoXimSave %s\n",name->string);
```



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```

video = FindVideo(name->string, global->videos);
whole_frame = (char *)MALLOC(video->size[0]*video->size[1]);
if (video->files[0] == '\0') strcpy(video->files.name->string);

sprintf(file_name, "%s%s/%s/%s%s\0", global->home, IMAGE_DIR, video->path, video-
>files, ".xim");
fp = fopen(file_name, "w");
sprintf(header.file_version, "%8d", IMAGE_VERSION);
sprintf(header.header_size, "%8d", 1024);
sprintf(header.image_width, "%8d", video->size[0]);
sprintf(header.image_height, "%8d", video->size[1]);
sprintf(header.num_colors, "%8d", 256);
sprintf(header.num_channels, "%8d", video->type == MONO?1:3);
sprintf(header.num_pictures, "%8d", video->size[2]);
sprintf(header.alpha_channel, "%4d", 0);
sprintf(header.runlength, "%4d", 0);
sprintf(header.author, "%48s", "xwave");
sprintf(header.date, "%32s", "Now");
sprintf(header.program, "%16s", "xwave");
for(i=0; i<256; i++) {
    header.c_map[i][0] = (unsigned char)i;
    header.c_map[i][1] = (unsigned char)i;
    header.c_map[i][2] = (unsigned char)i;
}
fwrite(&header, 1, sizeof(ImageHeader), fp);
for (frame = video->start; frame < video->start + video->size[2]; frame++) {
    GetFrame(video, frame-video->start);
    for(channel=0; channel < (video->type == MONO?1:3); channel++) {
        for(x=0; x < video->size[0]; x++)
            for(y=0; y < video->size[1]; y++)

whole_frame[x+video->size[0]*y] = itc(video->data[channel][frame-video->start][Addre

```

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```

ss(video.channel.x,y)] > > video->precision);
        fwrite(whole_frame,sizeof(char),video->size[0]*video->size[1],fp);
    }
    FreeFrame(video.frame-video->start);
}
fclose(fp);
XtFree(whole_frame);
}

```

```

void VideoMacSave(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t     closure, call_data;

```

```

{

```

```

    Video video;

```

```

    FILE *fp, *fopen();

```

```

    XawListReturnStruct *name=(XawListReturnStruct *)call_data;

```

```

    char file_name[STRLEN], *whole_frame;

```

```

    int frame, channel, i, x, y;

```

```

    Dprintf("VideoMacSave %s\n",name->string);

```

```

    video=FindVideo(name->string,global->videos);

```

```

    if (video->files[0] == '\0') strcpy(video->files,name->string);

```

```

    sprintf(file_name,"%s%s/%s/%s%s\0",global->home.IMAGE_DIR,video->path,video-
    >files, ".mac");

```

```

    fp=fopen(file_name,"w");

```

```

    whole_frame=(char *)MALLOC(video->size[1]*video->size[0]*3);

```

```

    for(frame=0;frame<video->size[2];frame++) {

```

```

        int size=video->size[0]*video->size[1];

```

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```

    GetFrame(video.frame);
    for(channel=0;channel < (video->type == MONO?1:3);channel++)
        for(x=0;x < video->size[0];x++)
            for(y=0;y < video->size[1];y++)

whole_frame[(x+video->size[0]*y)*3+channel]=itc(video->data[channel][frame][Address(video.channel,x,y)] >> video->precision);
    fwrite(whole_frame,1,3*size,fp);
    FreeFrame(video.frame);
}
fclose(fp);
XtFree(whole_frame);
}

```

```
void VideoHexSave(w.closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```

{
    Video video;
    FILE *fp, *fopen();
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    char file_name[STRLEN];
    int frame, channel, i;

    Dprintf("VideoHexSave %s\n",name->string);
    video=FindVideo(name->string,global->videos);
    if (video->files[0] == '\0') strcpy(video->files,name->string);

```

```

sprintf(file_name,"%s%s/%s/%s%s\0",global->home,IMAGE_DIR,video->path,video->files, ".h");

```

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```

fp = fopen(file_name, "w");
for(frame = 0; frame < (video->size[2] > 2?2:video->size[2]); frame++) {
    int    size = video->size[1]*video->size[0];

    GetFrame(video, frame);

    fprintf(fp, "char
%s%d[ %d] = {\n", name->string[strlen(name->string)-1] == 'd'? "src": "dst", frame, size);
    for(i = 0; i < size; i++)

fprintf(fp, "0x%02x, %c", (video->data[0][frame][i] > video->precision) + 128, i%20 ==
19?'\\n': ' ');

    fprintf(fp, "\\n};\\n");
    FreeFrame(video, frame);
}
fclose(fp);
}

```

```
#define AB_WIDTH 1440
```

```
#define AB_HEIGHT 486
```

```
void VideoAbekusSave(w, closure, call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```

{
    AbekusCtrl ctrl = (AbekusCtrl)closure;
    FILE *fp, *fopen();
    char file_name[STRLEN], *data = (char
*)MALLOC(AB_WIDTH*AB_HEIGHT), zero = itc(0);
    int frame, channel, i, x, y, length = 0;
    Video vids[4];

```

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```

Dprintf("VideoAbekusSave\n");
for(i=0;i<4;i++)
    if (ctrl->names[i]!=NULL) {
        vids[i]=FindVideo(ctrl->names[i],global->videos);
        length=length>vids[i]->size[2]?length:vids[i]->size[2];
    } else vids[i]=NULL;
for(frame=0;frame<length;frame++) {
    sprintf(file_name,"%d.yuv\0",frame+1);
    fp=fopen(file_name,"w");
    for(i=0;i<4;i++) GetFrame(vids[i],frame);
    for(y=0;y<AB_HEIGHT;y++)
        for(x=0;x<AB_WIDTH;x++) {
            int
i=(x<AB_WIDTH/2?0:1)+(y<AB_HEIGHT/2?0:2),
                                Y=y<AB_HEIGHT/2?y:y-AB_HEIGHT/2,
                                X=(x<AB_WIDTH/2?x:x-AB_WIDTH/2)/2,
                                channel=((x&1)==1)?0:((X&1)==0)?1:2;

                                if (vids[i]->type==MONO && channel!=0 ||
X>=vids[i]->size[0] || Y>=vids[i]->size[1]) data[x+y*AB_WIDTH]=zero;
                                else
data[x+y*AB_WIDTH]=itc(vids[i]->data[channel][frame][Address(vids[i],channel,X,Y)]
>>vids[i]->precision);
                                }
            for(i=0;i<4;i++) {
                FreeFrame(vids[i],frame);
                EraseFrame(vids[i],frame);
            }
            fwrite(data,1,AB_WIDTH*AB_HEIGHT,fp);
            fclose(fp);
        }
    }
}

```

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```
void VideoDrop(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
Video *videos=&global->videos, video;
```

```
XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
int  channel, frame;
```

```
Dprintf("VideoDrop %s\n",name->string);
```

```
video=FindVideo(name->string,global->videos);
```

```
while (*videos!=video && *videos!=NULL) videos=&((*videos)->next);
```

```
if (*videos!=NULL) {
```

```
    *videos=(*videos)->next;
```

```
    for(channel=0;channel<(video->type==MONO?1:3);channel++)
```

```
        if (video->data[channel]!=NULL) {
```

```
            for(frame=0;frame<video->size[2];frame++)
```

```
                if (video->data[channel][frame]!=NULL)
```

```
                    XtFree(video->data[channel][frame]);
```

```
                    XtFree(video->data[channel]);
```

```
        }
```

```
    XtFree(video);
```

```
}
```

```
}
```

```
/* Obsolete
```

```
void VideoDiff(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

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```

XawListReturnStruct *name=(XawListReturnStruct *)call_data;
Video src=FindVideo(name->string,global->videos), dst=CopyHeader(src);
int frame, channel, i;

printf("VideoDiff %s\n",name->string);
sprintf(dst->name,"%s.diff\0",src->name);
for(frame=0;frame<src->size[2];frame++) {
    GetFrame(src,frame);
    NewFrame(dst,frame);
    for(channel=0;channel<(video->type==MONO?1:3);channel++)
        for(i=0;i<src->size[1]*src->size[0];i++)

dst->data[channel][frame][i]=src->data[channel][frame][i]-(frame==0?0:src->data[channel][frame-1][i]);
    SaveFrame(dst,frame);
    FreeFrame(dst,frame);
    if (frame>0) FreeFrame(src,frame-1);
}
FreeFrame(dst,src->size[2]-1);
dst->next=global->videos;
global->videos=dst;
}
*/
void VideoClean(w,closure,call_data)

Widget w;
caddr_t closure, call_data;

{
    Video *videos=&global->videos, video;
    int channel, frame;

```

```

Dprintf("VideoClean\n");
while(*videos!=NULL) {
    video=*videos;
    if (False==VideoHasFrame(video,global->frames)) {
        Dprintf("Erasing video: %s\n",video->name);

for(channel=0;channel<(video->type==MONO?1:3);channel++)
        if (video->data[channel]!=NULL) {
            for(frame=0;frame<video->size[2];frame++)
                if (video->data[channel][frame]!=NULL)
XtFree(video->data[channel][frame]);
            XtFree(video->data[channel]);
        }
        *videos=video->next;
        XtFree(video);
    } else videos=&(*videos)->next;
}
}

typedef struct {
    Frame frame;
    XtIntervalId id;
    unsigned long interval;
    long msec, shown, average;
    Pixmap *movie;
    int fno, old_fno;
} MovieArgRec, *MovieArg;

void Projector(client_data,id)

XtPointer client_data;
XtIntervalId *id;

```



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```

{
    MovieArg    movieArg=(MovieArg)client_data;
    Display      *dpy=XtDisplay(global->toplevel);
    struct timeval    tp;
    struct timezone    tzp;
    long    new_msec;
    int    scrn=XDefaultScreen(dpy);

movieArg->id=XtAppAddTimeOut(global->app_con,movieArg->interval,Projector,mo
vieArg);
    gettimeofday(&tp,&tzp);
    new_msec=tp.tv_sec*1000+tp.tv_usec/1000;
    if (movieArg->msec!=0) {

movieArg->average=(movieArg->average*movieArg->shown+new_msec-movieArg-
>msec)/(movieArg->shown+1);
        movieArg->shown++;
    }
    movieArg->msec=new_msec;

XCopyArea(dpy,movieArg->movie[movieArg->fno],XtWindow(movieArg->frame->i
mage_widget),DefaultGC(dpy,scrn),0,0,movieArg->frame->video->size[0],movieArg-
>frame->video->size[1],0,0);

movieArg->fno=movieArg->fno==movieArg->frame->video->size[2]-1?0:movieAr
g->fno+1;
}

void    StopMovie(w,closure,call_data)

Widget    w;

```

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```
caddr_t      closure, call_data;
```

```
{
```

```
    MovieArg    movieArg=(MovieArg)closure;
```

```
    Display      *dpy=XtDisplay(global->toplevel);
```

```
    int          i;
```

```
    Arg          args[1];
```

```
    XtRemoveTimeout(movieArg->id);
```

```
    Dprintf("Movie showed %d frames at an average of %f\n",
movieArg->shown,1000.0/(float)movieArg->average);
```

```
    for(i=0;i<movieArg->frame->video->size[2];i++)
```

```
    XFreePixmap(dpy,movieArg->movie[i]);
```

```
    XtFree(movieArg->movie);
```

```
    XtSetArg(args[0],XtNbixmap,UpdateImage(movieArg->frame));
```

```
    XtSetValues(movieArg->frame->image_widget,args,ONE);
```

```
    XSynchronize(dpy,False);
```

```
}
```

```
#define      MOVIE_ICONS      1
```

```
void  Movie(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
```

```
    Video video=((Frame)closure)->video;
```

```
    MovieArg    movieArg=(MovieArg)MALLOC(sizeof(MovieArgRec));
```

```
    Widget      shell=ShellWidget("movie",XtParent(w),SW_over,NULL,NULL),
```

```
                form=FormWidget("movie_form",shell),
```

```
    widgets[MOVIE_ICONS];
```

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```

Display      *dpy = XtDisplay(globai->toplevel);
FormItem     items[] = {
    {"movie_stop", "stop", 0, 0, FW_icon, NULL},
};
XtCallbackRec callbacks[] = {
    {StopMovie, (caddr_t)movieArg},
    {Free, (caddr_t)movieArg},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
};
int          i;
XGCValues    values;
GC           gc;

Dprintf("Movie\n");

FillForm(form, MOVIE_ICONS, items, widgets, callbacks);
XtPopup(shell, XtGrabExclusive);

values.foreground = 255;
values.background = 0;
gc = XtGetGC(XtParent(w), GCForeground | GCBackground, &values);
movieArg->frame = (Frame)closure;
movieArg->movie = (Pixmap *)MALLOC(video->size[2]*sizeof(Pixmap));
movieArg->old_fno = movieArg->frame->frame;
for(i=0; i < video->size[2]; i++) {
    char    fno[STRLEN];

    sprintf(fno, "%03d\0", i+video->start);
    movieArg->frame->frame = i;
    GetFrame(video, i);
    movieArg->movie[i] = UpdateImage(movieArg->frame);
}

```

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```

XDrawImageString(dpy, movieArg->movie[i], gc, video->size[0]-50, 10.fno, 3);

XCopyArea(dpy, movieArg->movie[i], XtWindow(movieArg->frame->image_widget), D
efaultGC(dpy, 0), 0, 0, video->size[0], video->size[1], 0, 0);
    movieArg->frame->frame = movieArg->old_fno;
    FreeFrame(video, i);
}
XtDestroyGC(gc);
movieArg->fno = 0;
movieArg->msec = 0;
movieArg->shown = 0;
movieArg->average = 0;
movieArg->interval = 1000/video->rate;

movieArg->id = XtAppAddTimeOut(global->app_con, movieArg->interval, Projector, mo
vieArg);
    XSynchronize(dpy, True);
}

void Compare(w, closure, call_data)

Widget      w;
caddr_t     closure, call_data;

{
    XawListReturnStruct *name = (XawListReturnStruct *)call_data;
    Video src = (Video)closure, dst = FindVideo(name->string, global->videos);
    int channels = src->type == MONO || dst->type == MONO ? 1 : 3, channel,
values = 0, x, y,
        frames = src->size[2] > dst->size[2] ? dst->size[2] : src->size[2],
frame;

```

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```

double      mse;
Message      msg = NewMessage(NULL,400);
XtCallbackRec  callbacks[] = {
    {CloseMessage,(caddr_t)msg}, {NULL,NULL},
};

msg->rows = frames > 5 ? 10 : 2 * frames; msg->cols = 40;
if (global->batch == NULL)
MessageWindow(FindWidget("frm_compare",w),msg,"Compare",True,callbacks);
for(frame = 0; frame < frames; frame++) {
    Boolean      srcp = src->precision > dst->precision;
    int          err_sqr = 0,
precision = srcp ? src->precision - dst->precision : dst->precision - src->precision;

    Mprintf(msg,"Compare: %s%03d and
%s%03d\n",src->name,src->start + frame,dst->name,dst->start + frame);
    GetFrame(src,frame);
    GetFrame(dst,frame);
    for(channel = 0; channel < channels; channel++) {

values += Size(src->size[1] > dst->size[1] ? dst:src,channel,1) * Size(src->size[0] > dst->s
ize[0] ? dst:src,channel,0);

for(y = 0; y < Size(src->size[1] > dst->size[1] ? dst:src,channel,1); y++)

for(x = 0; x < Size(src->size[0] > dst->size[0] ? dst:src,channel,0); x++) {
        int
err = (src->data[channel][frame][x + Size(src,channel,0)*y] < < (srcp ? 0:precision)) - (dst->
data[channel][frame][x + Size(dst,channel,0)*y] < < (srcp ? precision:0));

        err_sqr += err*err;
    }
}

```

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```

    }
    FreeFrame(src.frame);
    FreeFrame(dst.frame);
    mse = (double)err_sqr/(double)(values);
    Mprintf(msg, "Error %d MSE %f PSNR
    %f\n", err_sqr, mse, 10*log10(pow((pow(2.0, (double)(8 + (srcp?src->precision:dst->precis
    ion)))-1), 2.0)/mse));
    Mflush(msg);
  }
}

```

```

void BatchCompare(w, closure, call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{
    String name = (String)closure;

    closure = (caddr_t)FindVideo(name, global->videos);
    Compare(w, closure, call_data);
}

```

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source/xwave.c

```
#include    "../include/xwave.h"
#include    <X11/Xresource.h>
#include    <X11/Intrinsic.h>
#include    <X11/Quarks.h>

extern Palette    ReOrderPalettes();
extern void    NameButton();
extern void    ImageNotify();
extern void    Parse();

#define    IconPath    "bitmaps"
#define    IconFile    "xwave.icons"
#define    CompressPath    "."
#define    CompressExt    ".compress"
#define    PalettePath    "."
#define    PaletteExt    ".pal"

Global    global;

String    ChannelName[3][4]={
    {"GreyScale",NULL,NULL,NULL},
    {"Red  ", "Green", "Blue ", "Color"},
    {"Y-Lumunance", "U-Chrome  ", "V-Chrome  ", "Color  "},
};

#define    XtNdebug    "debug"
#define    XtNbatch    "batch"
```

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```

static XtResource  resources[] = {
    {XtNdebug, XtCBoolean, XtRBoolean, sizeof(Boolean),
    XtOffset(Global.debug), XtRString, "false"},
    {XtNbatch, XtCFile, XtRString, sizeof(String),
    XtOffset(Global.batch), XtRString, NULL},
};

static XrmOptionDescRec  options[]={
    {"-debug","*debug",XrmoptionNoArg,"true"},
    {"-batch","*batch",XrmoptionSepArg,NULL},
};

static Boolean      CvtStringToPixel20;

#if defined(__STDC__)
externref  XtConvertArgRec  const colorConvertArgs[2];
#else
externref XtConvertArgRec colorConvertArgs[2];
#endif

static String fallback_resources[]={
    "**copy_video*Toggle*translations: #override \\n <Btn1Down>,<Btn1Up>:
set() notify()",
    "**copy_video*copy*state: true",
    NULL,
};

XtActionsRec      actionTable[]={
    {"NameButton",NameButton},
};

main(argc,argv,envp)

```



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```
int    argc;
char   *argv[], *envp[];

{
    void    InitPixmaps(), InitActions(), InitMain(), InitEnv(), InitDither(), Dispatch();
    GlobalRec    globalrec;

    global = &globalrec;
    global->videos = NULL;
    global->frames = NULL;
    global->points = NULL;
    InitEnv(envp);

    global->toplevel = XtAppInitialize(&(global->app_con), "xwave", options, XtNumber(options),
    &argc, argv, fallback_resources, NULL, ZERO);

    XtGetApplicationResources(global->toplevel, global, resources, XtNumber(resources), NULL, ZERO);
    if (global->batch != NULL) {
        Parse(BATCH_DIR, global->batch, BATCH_EXT);
        if (global->batch_list != NULL) Dispatch(global->batch_list);
    }
    if (global->batch == NULL) {
        XtAppAddActions(global->app_con, actionTable, XtNumber(actionTable));

    XtSetTypeConverter(XtRString, XtRPixel, CvtStringToPixel2, colorConvertArgs, XtNumber(
    colorConvertArgs), XtCacheByDisplay, NULL);

        if (global->debug) Dprintf("Xwave Debugging Output\n");
        InitVisual();
        InitDither();
        InitPixmaps(IconPath, IconFile);
        Parse(PalettePath, "xwave", PaletteExt);
    }
```

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```

        global->palettes = ReOrderPalettes(global->palettes, global->palettes);
        InitActions(global->app_con);
        InitMain();
        XtRealizeWidget(global->toplevel);
        XtAppMainLoop(global->app_con);
    }
}

```

```
void InitEnv(envp)
```

```
char *envp[];
```

```

{
    String home=NULL, xwave=NULL;

    Dprintf("Initializing enviroment\n");
    while(*envp!=NULL) {
        if(!strcmp(*envp, "HOME=", 5)) home = (*envp) + 5;
        if(!strcmp(*envp, "XWAVE=", 6)) xwave = (*envp) + 6;
        envp++;
    }
    if (xwave!=NULL) sprintf(global->home, "%s/", xwave);
    else sprintf(global->home, "%s/xwave/", home);
}

```

```
#define HEIGHT 14
```

```
void InitPixmap(path, file)
```

```
char *file, *path;
```

```
{
```

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```

FILE *fp, *fopen();
Icon icons;
char pad[100];
Display *dpy = XtDisplay(global->toplevel);
int i, j, sink, scrn = XDefaultScreen(dpy), depth = DisplayPlanes(dpy, scrn),
    bpl = (global->levels*depth + 7)/8;
char data[HEIGHT*bpl];
XImage
*image = XCreateImage(dpy, global->visinfo->visual, depth, ZPixmap, 0, data, global->levels, HEIGHT, 8, bpl);

```

```

    sprintf(pad, "%s%s/%s\0", global->home, path, file);
    if (NULL == (fp = fopen(pad, "r"))) {
        fprintf("Can't open file %s\n", pad);
        exit();
    }
    fscanf(fp, "%d\n", &global->no_icons);
    global->icons = (Icon)MALLOC((1 + global->no_icons)*sizeof(IconRec));
    for(i=0; i < global->no_icons; i++) {
        global->icons[i].name = (String)MALLOC(100);
        fscanf(fp, "%s\n", global->icons[i].name);
        sprintf(pad, "%s%s/%s\0", global->home, path, global->icons[i].name);
        XReadBitmapFile(
            XtDisplay(global->toplevel),
            XDefaultRootWindow(dpy),
            pad,
            &global->icons[i].width,
            &global->icons[i].height,
            &global->icons[i].pixmap,
            &sink,
            &sink
        );
    }

```

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```

    }
    global->icons[global->no_icons].name=(String)MALLOC(100);
    strcpy(global->icons[global->no_icons].name,"colors");
    global->icons[global->no_icons].width=global->levels;
    global->icons[global->no_icons].height=HEIGHT;
    for(i=0;i<global->levels;i++)
        for(j=0;j<HEIGHT;j++) XPutPixel(image,i,j,i);

    global->icons[global->no_icons].pixmap=XCreatePixmap(dpy,XDefaultRootWindow(dp
y),global->levels,HEIGHT,depth);

    XPutImage(dpy,global->icons[global->no_icons].pixmap,DefaultGC(dpy,scrn),image,0,0
,0,0,global->levels,HEIGHT);
    global->no_icons++;
    XtFree(image);
    fclose(fp);
}

#define done(type, value) \
{ \
    if (toVal->addr != NULL) { \
        if (toVal->size < sizeof(type)) { \
            toVal->size = sizeof(type); \
            return False; \
        } \
        *(type*)(toVal->addr) = (value); \
    } \
    else { \
        static type static_val; \
        static_val = (value); \
        toVal->addr = (XtPointer)&static_val; \
    } \
}

```

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```

        toVal->size = sizeof(type);
        return True;
    }

#define      dist(colora,colorb) \

abs(colora.red-colorb.red)+abs(colora.green-colorb.green)+abs(colora.blue-colorb.blue)

static Boolean CvtStringToPixel2(dpy, args, num_args, fromVal, toVal, closure_ret)
    Display*  dpy;
    XrmValuePtr args;
    Cardinal  *num_args;
    XrmValuePtr  fromVal;
    XrmValuePtr  toVal;
    XtPointer  *closure_ret;
{
    String      str = (String)fromVal->addr;
    XColor       screenColor;
    XColor       exactColor;
    Screen       *screen;
    Colormap     colormap;
    Status       status;
    String       params[1];
    Cardinal     num_params=1;

    Dprintf("Convert string to pixel 2\n");
    if (*num_args != 2)
        XtAppErrorMsg(XtDisplayToApplicationContext(dpy), "wrongParameters",
            "cvtStringToPixel",
                "XtToolkitError",
                "String to pixel conversion needs screen and colormap arguments",
                (String *)NULL, (Cardinal *)NULL);

```

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```

screen = *((Screen **) args[0].addr);
colormap = *((Colormap *) args[1].addr);

if (!strcmp(str,XtDefaultBackground)) {
    *closure_ret = False;
    done(Pixel,WhitePixelOfScreen(screen));
}
if (!strcmp(str,XtDefaultForeground)) {
    *closure_ret = False;
    done(Pixel,BlackPixelOfScreen(screen));
}
params[0]=str;
if (0==XParseColor(DisplayOfScreen(screen),colormap,str,&screenColor)) {
    XtAppWarningMsg(XtDisplayToApplicationContext(dpy), "noColormap",
"cvStringToPixel",
    "XtToolkitError", "Cannot parse color: \"%s\"",
params,&num_params);
    return False;
} else {
    if (0==XAllocColor(DisplayOfScreen(screen),colormap,&screenColor)) {
        int    i, delta, closest=0;
        XColor    colors[global->levels];

        for(i=0;i<global->levels;i++) colors[i].pixel=i;

XQueryColors(DisplayOfScreen(screen),colormap,colors,global->levels);
        delta=dist(screenColor,colors[0]);
        for(i=1;i<global->levels;i++) {
            int    delta_new=dist(screenColor,colors[i]);

            if (delta_new<delta) {
                delta=delta_new;

```

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```

        closest=i;
    }
}
Dprintf("Closest color to %s is pixel %d red %d green %d blue
%d\n",str,colors[closest].pixel,colors[closest].red,colors[closest].green,colors[closest].blue
);
        *closure_ret = (char*)True;
        done(Pixel, closest);
    } else {
        *closure_ret = (char*)True;
        done(Pixel, screenColor.pixel);
    }
}
}

```

```
void Dispatch(list)
```

```
Batch list;
```

```

{
    if (list->next!=NULL) Dispatch(list->next);
    (list->proc)(NULL,list->closure,list->call_data);
    if (list->closure!=NULL) XtFree(list->closure);
    if (list->call_data!=NULL) XtFree(list->call_data);
    XtFree(list);
}

```

```
void BatchCtrl(w,closure,call_data)
```

```

Widget      w;
caddr_t     closure, call_data;

```

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```

{
    Dprintf("BatchCtrl\n");
    global->batch=(String)closure;
}

```

```

void UnixShell(w,closure.call_data)

```

```

Widget      w;
caddr_t     closure.call_data;

```

```

{
    if (-1 == Fork((char **)closure)) Eprintf("Unable to fork\n");
}

```

```

void InitDither()

```

```

{
    int      i, j, k, l,
            dm4[4][4]={
                0, 8, 2, 10,
                12, 4, 14, 6,
                3, 11, 1, 9,
                15, 7, 13, 5
            };

    for(i=0;i<4;i++)
        for(j=0;j<4;j++)
            for(k=0;k<4;k++)
                for(l=0;l<4;l++)

global->dither[4*k+i][4*l+j]=(dm4[i][j]<<4)+dm4[k][l];
}

```



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source/Copy.h

```
typedef struct {  
    Video video;  
    char name[STRLEN], src_name[STRLEN];  
    int UVsample[2];  
    int mode;  
    Widget radioGroup;  
} CopyCtrlRec, *CopyCtrl;
```

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source/Gram.y

%{

/\*

\* Grammar for files: .elo

\*/

#include "../include/xwave.h"

#include "Klics.h"

#include "Transform.h"

#include "Copy.h"

#include "Video.h"

extern void VideoLoad();

extern void VideoSave();

extern void VideoDrop();

extern void ImportKlics();

extern void VideoAbekusSave();

extern void UnixShell();

extern void BatchCompCtrl();

extern void BatchTransCtrl();

extern void BatchCopyCtrl();

extern void BatchCompare();

extern void BatchCtrl();

extern CompCtrl InitCompCtrl();

extern CopyCtrl InitCopyCtrl();

extern TransCtrl InitTransCtrl();

static char \*ptr;

void NewBatch();

%}

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%union

{

double fnum;

int num;

char \*ptr;

Boolean bool;

};

%token SIZE TRANSFORM TRANSFORM\_NONE TRANSFORM\_WAVE PATH

%token FILE\_PAL PALETTE RANGE LINE

%token FILE\_VID TYPE FORMAT\_MONO FORMAT\_RGB FORMAT\_YUV

RATE DISK GAMMA PATH FILES START END LEN DIM HEADER OFFSETS

NEGATIVE PRECISION

%token FILE\_BAT LOAD SAVE SAVE\_ABEKUS COMPARE DROP

COMPRESS VIDEO\_NAME STATS\_NAME BIN\_NAME

%token STILL\_MODE VIDEO\_MODE AUTO\_Q QUANT\_CONST

THRESH\_CONST BASE\_FACTOR DIAG\_FACTOR CHROME\_FACTOR

%token DECISION DEC\_MAX DEC\_SIGABS DEC\_SIGSQR FEEDBACK

FILTER FLT\_NONE FLT\_EXP CMP\_CONST SPACE LEFT\_BRACE RIGHT\_BRACE

DIRECTION

%token FPS BITRATE BUFFER XWAVE SHELL IMPORT\_KLICS

%token COPY DIRECT\_COPY DIFF LPF\_WIPE LPF\_ONLY RGB\_YUV

%token &lt; num &gt; NUMBER

%token &lt; ptr &gt; STRING

%token &lt; fnum &gt; FNUMBER

%token &lt; bool &gt; BOOLEAN

%type &lt; num &gt; number video\_type decision filter

%type &lt; ptr &gt; string

%type &lt; fnum &gt; fnumber

%type &lt; bool &gt; boolean

- 404 -

```
%start wait
```

```
% %
```

```
wait :
```

```
    | pal_id pal_desc
    | video_id video_desc
    | bat_id bat_desc bat_end;
```

```
pal_id : FILE_PAL {
```

```
    Dprintf("Gram: palette file %s\n",global->parse_file);
```

```
};
```

```
video_id : FILE_VID {
```

```
    Dprintf("Gram: video file %s\n",global->parse_file);
```

```
    global->videos->start=1;
```

```
    global->videos->size[2]=1;
```

```
};
```

```
bat_id : FILE_BAT {
```

```
    Dprintf("Gram: batch file %s\n",global->parse_file);
```

```
};
```

```
pal_desc :
```

```
    | pal_desc palette LEFT_BRACE mappings RIGHT_BRACE;
```

```
palette : PALETTE string {
```

```
    Palette pal=(Palette)MALLOC(sizeof(PaletteRec));
```

```
    Dprintf("Gram: palette %s\n", $2);
```

```
    strcpy(pal->name,$2);
```

```
    pal->mappings=NULL;
```

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```
pal->next=global->palettes;
```

```
global->palettes=pal;
```

```
global->no_pals++;
```

```
};
```

```
mappings :
```

```
| mappings mapping;
```

```
mapping : RANGE number number LINE number number {
```

```
Map map=(Map)MALLOC(sizeof(MapRec));
```

```
Dprintf("Gram: Range %d to %d m=%d c=%d\n", $2, $3, $5, $6);
```

```
map->start=$2;
```

```
map->finish=$3;
```

```
map->m=$5;
```

```
map->c=$6;
```

```
map->next=global->palettes->mappings;
```

```
global->palettes->mappings=map;
```

```
};
```

```
video_desc : video_defs {
```

```
if (global->videos->size[0]==0 &&
```

```
global->videos->size[1]==0) {
```

```
global->videos->size[0]=global->videos->cols;
```

```
global->videos->size[1]=global->videos->rows;
```

```
}
```

```
};
```

```
video_defs :
```

```
| video_defs video_def;
```

```
video_def : PATH string {
```

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```
Dprintf("Video path %s\n", $2);
strcpy(global->videos->path, $2);
}
| FILES string {
    Dprintf("Frames stored in %s\n", $2);
    strcpy(global->videos->files, $2);
}
| TYPE video_type {
    String types[] = {"Mono", "RGB", "YUV"};

    Dprintf("Video type: %s\n", types[$2]);
    global->videos->type = (VideoFormat)$2;
}
| RATE number {
    Dprintf("Video rate %d fps\n", $2);
    global->videos->rate = $2;
}
| DISK {
    Dprintf("Frames on disk\n");
    global->videos->disk = True;
}
| GAMMA {
    Dprintf("Gamma corrected\n");
    global->videos->gamma = True;
}
| NEGATIVE {
    Dprintf("Negative video\n");
    global->videos->negative = True;
}
| TRANSFORM video_transform
| START number {
    Dprintf("Video start %03d\n", $2);
```

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```
        global->videos->start=$2;
    }
    | END number {
        Dprintf("Video end %03d\n",$2);
        global->videos->size[2]=$2-global->videos->start+1;
    }
    | LEN number {
        Dprintf("Video frames %d\n",$2);
        global->videos->size[2]=$2;
    }
    | DIM number number {
        Dprintf("Video dimensions %d %d\n",$2,$3);
        global->videos->cols=$2;
        global->videos->rows=$3;
    }
    | HEADER number {
        Dprintf("Video header size %d\n",$2);
        global->videos->offset=$2;
    }
    | OFFSETS number number {
        Dprintf("Video offsets %d %d\n",$2,$3);
        global->videos->x_offset=$2;
        global->videos->y_offset=$3;
    }
    | SIZE number number {
        Dprintf("Video size %d %d\n",$2,$3);
        global->videos->size[0]=$2;
        global->videos->size[1]=$3;
    }
    | PRECISION number {
        Dprintf("Video precision %d bits\n",8+$2);
        global->videos->precision=$2;
```

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```

};

video_type : FORMAT_MONO { $$=(int)MONO; }
           | FORMAT_RGB { $$=(int)RGB; }
           | FORMAT_YUV number number { $$=(int)YUV;
global->videos->UVsample[0]=$2; global->videos->UVsample[1]=$3; };

video_transform : TRANSFORM_NONE {
                global->videos->trans.type=TRANS_None;
                }
                | TRANSFORM_WAVE number number boolean {
                Dprintf("Video wavelet tranformed %d %d
%s\n", $2, $3, $4?"True":"False");
                global->videos->trans.type=TRANS_Wave;
                global->videos->trans.wavelet.space[0]=$2;
                global->videos->trans.wavelet.space[1]=$3;
                global->videos->trans.wavelet.dirn=$4;
                };

bat_end :
        | XWAVE {
                Dprintf("Gram: XWAVE\n");
                NewBatch(BatchCtrl, (caddr_t) NULL, NULL);
        };

bat_desc : bat_cmds {
                Dprintf("Gram: End of batch file\n");
        };

bat_cmds :
        | bat_cmds bat_cmd;

```



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```

bat_cmd      : simple_cmd
               | complex_cmd
               ;

simple_cmd    : LOAD string {
               XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

               Dprintf("Gram: LOAD %s\n", $2);
               list_return->string = $2;
               NewBatch(VideoLoad, NULL, (caddr_t)list_return);
               }
               | SAVE string {
               XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

               Dprintf("Gram: SAVE %s\n", $2);
               list_return->string = $2;
               NewBatch(VideoSave, NULL, (caddr_t)list_return);
               }
               | SAVE_ABEKUS string string string string {
               AbekusCtrl
ctrl=(AbekusCtrl)MALLOC(sizeof(AbekusCtrlRec));

               Dprintf("Gram: SAVE_ABEKUS %s %s %s
%s\n", $2, $3, $4, $5);
               strcpy(ctrl->names[0], $2);
               strcpy(ctrl->names[1], $3);
               strcpy(ctrl->names[2], $4);
               strcpy(ctrl->names[3], $5);
               NewBatch(VideoAbekusSave, (caddr_t)ctrl, NULL);
               }

```

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```

| COMPARE string string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: COMPARE %s with %s\n", $2, $3);
    list_return->string = $2;
    NewBatch(BatchCompare, (caddr_t)$3, (caddr_t)list_return);
}

| DROP string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: DROP %s\n", $2);
    list_return->string = $2;
    NewBatch(VideoDrop, NULL, (caddr_t)list_return);
}

| IMPORT_KLICS string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: IMPORT_KLICS %s\n", $2);
    list_return->string = $2;
    NewBatch(ImportKlics, NULL, (caddr_t)list_return);
}

| SHELL string {
    char **argv, *str = $2;
    int c, argc = 1, len = strlen(str);

    Dprintf("Shell %s\n", str);
    for(c=0; c < len; c++) if (str[c] == ' ') {
        str[c] = '\0';
        argc++;
    }
}

```

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```

    }
    argv=(char **)MALLOC((argc+1)*sizeof(char *));
    argc=0;
    for(c=0;c < len;c += 1+strlen(str+c)) {
        argv[argc]=(char
*)MALLOC((strlen(str+c)+1)*sizeof(char));
        strcpy(argv[argc],str+c);
        argc++;
    }
    argv[argc]=NULL;
    NewBatch(UnixShell,(caddr_t)argv,NULL);
};

```

```

complex_cmd      : compress LEFT_BRACE comp_args RIGHT_BRACE
                  | transform LEFT_BRACE trans_args RIGHT_BRACE
                  | copy copy_arg;

```

```

compress        : COMPRESS string {
                  CompCtrl    ctrl=InitCompCtrl($2);

                  Dprintf("Gram: COMPRESS\n");
                  NewBatch(BatchCompCtrl,(caddr_t)ctrl,NULL);
                };

```

```

transform       : TRANSFORM string {
                  TransCtrl    ctrl=InitTransCtrl($2);

                  Dprintf("Gram: TRANSFORM\n");
                  NewBatch(BatchTransCtrl,(caddr_t)ctrl,NULL);
                };

```

```

copy            : COPY string string {

```

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```

CopyCtrl    ctrl=InitCopyCtrl($2);
Dprintf("Gram: Copy\n");
strcpy(ctrl->name,$3);
NewBatch(BatchCopyCtrl,(caddr_t)ctrl,NULL);
};

comp_args    :
    | comp_args comp_arg;

trans_args    :
    | trans_args trans_arg;

copy_arg      : DIRECT_COPY number number {
    Dprintf("Gram: Direct Copy (sample %d %d)\n", $2, $3);
    ((CopyCtrl)global->batch_list->closure)->mode=1;

    ((CopyCtrl)global->batch_list->closure)->UVsample[0]=$2;

    ((CopyCtrl)global->batch_list->closure)->UVsample[1]=$3;
    }
    | DIFF {
    Dprintf("Gram: Difference Copy\n");
    ((CopyCtrl)global->batch_list->closure)->mode=2;
    }
    | LPF_WIPE {
    Dprintf("Gram: LPF zero\n");
    ((CopyCtrl)global->batch_list->closure)->mode=3;
    }
    | LPF_ONLY {
    Dprintf("Gram: LPF only\n");
    ((CopyCtrl)global->batch_list->closure)->mode=4;
    }

```

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```

| RGB_YUV {
    Dprintf("Gram: RGB/YUV\n");
    ((CopyCtrl)global->batch_list->closure)->mode=5;
}
| GAMMA {
    Dprintf("Gram: Gamma convert\n");
    ((CopyCtrl)global->batch_list->closure)->mode=6;
};

```

```

comp_arg : VIDEO_NAME string {
    Dprintf("Gram: Compress name %s\n", $2);

```

```

strcpy(((CompCtrl)global->batch_list->closure)->name, $2);
}

```

```

| STATS_NAME string {
    Dprintf("Gram: Stats name %s\n", $2);

```

```

strcpy(((CompCtrl)global->batch_list->closure)->stats_name, $2);

```

```

((CompCtrl)global->batch_list->closure)->stats_switch=True;
}

```

```

| BIN_NAME string {
    Dprintf("Gram: Bin name %s\n", $2);

```

```

strcpy(((CompCtrl)global->batch_list->closure)->bin_name, $2);

```

```

((CompCtrl)global->batch_list->closure)->bin_switch=True;
}

```

```

| STILL_MODE {
    Dprintf("Gram: Still\n");
    ((CompCtrl)global->batch_list->closure)->stillvid=True;
}

```

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```

| VIDEO_MODE {
    Dprintf("Gram: Video\n");
    ((CompCtrl)global->batch_list->closure)->stillvid=False;
}
| AUTO_Q boolean {
    Dprintf("Gram: Auto_q %s\n", $2?"True":"False");
    ((CompCtrl)global->batch_list->closure)->auto_q=$2;
}
| QUANT_CONST fnumber {
    Dprintf("Gram: Quant const %f\n", $2);

((CompCtrl)global->batch_list->closure)->quant_const=$2;
}
| THRESH_CONST fnumber {
    Dprintf("Gram: Thresh const %f\n", $2);

((CompCtrl)global->batch_list->closure)->thresh_const=$2;
}
| BASE_FACTOR number fnumber {
    Dprintf("Gram: Base factor oct %d = %f\n", $2, $3);

((CompCtrl)global->batch_list->closure)->base_factors[$2]=$3;
}
| DIAG_FACTOR fnumber {
    Dprintf("Gram: Diag factor %f\n", $2);
    ((CompCtrl)global->batch_list->closure)->diag_factor=$2;
}
| CHROME_FACTOR fnumber {
    Dprintf("Gram: Chrome factor %f\n", $2);

((CompCtrl)global->batch_list->closure)->chrome_factor=$2;
}

```

```
| DECISION decision {
    Dprintf("Gram: Decision changed\n");
    ((CompCtrl)global->batch_list->closure)->decide = $2;
}
| FEEDBACK number {
    ((CompCtrl)global->batch_list->closure)->feedback = $2;
    ((CompCtrl)global->batch_list->closure)->auto_q = True;
}
| FILTER filter {
    String filters[2]={"None","Exp"};
    Dprintf("Gram: Filter %s\n",filters[$2]);
    ((CompCtrl)global->batch_list->closure)->filter = $2;
}
| CMP_CONST fnumber {
    Dprintf("Gram: Comparison %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->cmp_const = $2;
}
| FPS fnumber {
    Dprintf("Gram: Frame Rate %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->fps = $2;
}
| BITRATE number {
    Dprintf("Gram: %dx64k/s\n",$2);
    ((CompCtrl)global->batch_list->closure)->bitrate = $2;
}
| BUFFER {
    Dprintf("Gram: Buffer on\n");

    ((CompCtrl)global->batch_list->closure)->buf_switch = True;
};
```

```
decision      : DEC_MAX{ $$ = 0; }
```

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```

| DEC_SIGABS { $$ = 1; }
| DEC_SIGSQR { $$ = 2; };

```

```

filter      : FLT_NONE { $$ = 0; }
              | FLT_EXP { $$ = 1; };

```

```

trans_arg   : VIDEO_NAME string {
                Dprintf("Gram: Transform name %s\n", $2);

```

```

strcpy(((TransCtrl)global->batch_list->closure)->name, $2);
        }
        | DIRECTION boolean {
            Dprintf("Gram: Direction %s\n", $2?"True":"False");
            ((TransCtrl)global->batch_list->closure)->dirn=$2;
        }
        | SPACE number number {
            Dprintf("Gram: Space %d %d\n", $2, $3);
            ((TransCtrl)global->batch_list->closure)->space[0]=$2;
            ((TransCtrl)global->batch_list->closure)->space[1]=$3;
        }
        | PRECISION number {
            Dprintf("Gram: Precision %d bits\n", 8+$2);
            ((TransCtrl)global->batch_list->closure)->precision=$2;
        };

```

```

boolean     : BOOLEAN { $$ = $1; };

```

```

string : STRING {
    ptr = (char *)malloc(strlen($1)+1);
    strcpy(ptr, 1+$1);
    ptr[strlen(ptr)-1] = '\0';
    $$ = ptr;

```



};

fnumber : FNUMBER { \$\$ = \$1; };

number : NUMBER { \$\$ = \$1; };

%%

```
yyerror(s) char *s; {  
    Eprintf("Gram: error %s\n",s);  
    exit(3);  
}
```

void NewBatch(proc,closure,call\_data)

Proc proc;

caddr\_t closure, call\_data;

```
{  
    Batch bat=(Batch)MALLOC(sizeof(BatchRec));  
  
    bat->proc=proc;  
    bat->closure=closure;  
    bat->call_data=call_data;  
    bat->next=global->batch_list;  
    global->batch_list=bat;  
}
```

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source/Klics.h

/\* Block size - no not change \*/

#define BLOCK 2

typedef int Block[BLOCK][BLOCK]; /\* small block \*/

/\* tokens \*/

#define TOKENS 15

#define ZERO\_STILL 0

#define NON\_ZERO\_STILL 1

#define BLOCK\_SAME 2

#define ZERO\_VID 3

#define BLOCK\_CHANGE 4

#define LOCAL\_ZERO 5

#define LOCAL\_NON\_ZERO 6

#define CHANNEL\_ZERO 7

#define CHANNEL\_NON\_ZERO 8

#define OCT\_ZERO 9

#define OCT\_NON\_ZERO 10

#define LPF\_ZERO 11

#define LPF\_NON\_ZERO 12

#define LPF\_LOC\_ZERO 13

#define LPF\_LOC\_NON\_ZERO 14

static int token\_bits[TOKENS]

={1,1,1,2,2,1,1,1,1,1,1,1,1,1,1};

static unsigned char token\_codes[TOKENS]={0,1,0,1,3,0,1,0,1,0,1,0,1,0,1};

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/\* decision algorithms \*/

#define MAXIMUM 0

#define SIGABS 1

#define SIGSQR 2

/\* compression modes \*/

#define STILL 0

#define SEND 1

#define VOID 2

#define STOP 3

/\* LookAhead histogram \*/

#define HISTO 400

#define HISTO\_DELTA 20.0

#define HISTO\_BITS 9

#include "../include/Bits.h"

typedef struct {

Video src, dst;

Boolean stillvid, stats\_switch, bin\_switch, auto\_q, buf\_switch;

double quant\_const, thresh\_const, cmp\_const, fps,  
base\_factors[5], diag\_factor, chrome\_factor;

int bitrate, feedback, decide, filter;

char name[STRLEN], stats\_name[STRLEN], bin\_name[STRLEN],

src\_name[STRLEN];

Bits bfp;

} CompCtrlRec, \*CompCtrl;

typedef struct {

Boolean stillvid, auto\_q, buf\_switch;

double quant\_const, thresh\_const, cmp\_const, fps,

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```

        base_factors[5], diag_factor, chrome_factor;
int    decide;
VideoFormat type;
Boolean    disk, gamma;
int    rate, start, size[3], UVsample[2];
VideoTrans    trans;
int    precision;
} KlicsHeaderRec, *KlicsHeader;

```

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source/KlicsSA.h

#include &lt;stdio.h&gt;

#include "Bits.h"

#define negif(bool,value) ((bool)?-(value):(value))

extern Bits bopen();

extern void bclose(), bread(), bwrite(), bflush();

/\* Stand Alone definitions to replace VideoRec &amp; CompCtrl assumes:

- \* video->type == YUV;
- \* video->UVsample[] = {1,1};
- \* video->trans.wavelet.space[] = {3,2};
- \* ctrl->bin\_switch == True;
- \*/

#define SA\_WIDTH 352

#define SA\_HEIGHT 288

#define SA\_PRECISION 2

static double base\_factors[5]={1.0,0.32,0.16,0.16,0.16};

#define diag\_factor 1.4142136

#define chrome\_factor 2.0

#define thresh\_const 0.6

#define cmp\_const 0.9

/\* Block size - no not change \*/

#define BLOCK 2

typedef int Block[BLOCK][BLOCK]; /\* small block \*/

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```
/* tokens */
#define      TOKENS      15

#define ZERO_STILL      0
#define NON_ZERO_STILL  1
#define BLOCK_SAME      2
#define ZERO_VID        3
#define BLOCK_CHANGE    4
#define LOCAL_ZERO      5
#define LOCAL_NON_ZERO  6
#define CHANNEL_ZERO    7
#define CHANNEL_NON_ZERO 8
#define OCT_ZERO        9
#define OCT_NON_ZERO    10
#define LPF_ZERO        11
#define LPF_NON_ZERO    12
#define LPF_LOC_ZERO    13
#define LPF_LOC_NON_ZERO 14

static int          token_bits[TOKENS]
={1,1,1,2,2,1,1,1,1,1,1,1,1,1,1};
static unsigned char token_codes[TOKENS]={0,1,0,1,3,0,1,0,1,0,1,0,1,0,1};

/* decision algorithms */
#define MAXIMUM 0
#define SIGABS 1
#define SIGSQR 2

/* compression modes */
#define STILL 0
#define SEND 1
#define VOID 2
```

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#define STOP 3

/\* LookAhead histogram \*/

#define HISTO 400

#define HISTO\_DELTA 20.0

#define HISTO\_BITS 9

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source/Lex.l

%{

/\*

\* Lex driver for input files: .pal .vid .bat

\*/

#include "../include/xwave.h"

#include "../include/Gram.h"

extern int ParseInput();

#undef unput

#undef input

#undef output

#undef feof

#define unput(c) ungetc(c, global-&gt;parse\_fp)

#define input() ParseInput(global-&gt;parse\_fp)

#define output(c) putchar(c)

#define feof() (1)

%}

number -?[0-9]+

fnumber -?[0-9]+ "."[0-9]+

string \"([^\"]|\\.)\*\"&gt;

%start WAIT MAP VIDEO BATCH BATCH\_TRANS BATCH\_COMP

%n 2000

%p 4000

%e 2000



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%%

```

/* { char c = '\0';

```

```

    while(c != '/') {
        while (c != '*') c = input();
        while (c == '*') c = input();
    }
}

```

```

\pal { BEGIN MAP; Dprintf("Lex: Reading palette file\n"); return(FILE_PAL); }
\vid { BEGIN VIDEO; Dprintf("Lex: Reading video file\n"); return(FILE_VID); }
\bat { BEGIN BATCH; Dprintf("Lex: Reading batch file\n"); return(FILE_BAT); }

```

```

{number}      { (void)sscanf(yytext, "%d", &yyval.num); return(NUMBER); }
{string}      { yyval.ptr = (char *)yytext; return(STRING); }
{fnumber}     { (void)sscanf(yytext, "%lf", &yyval.fnum); return(FNUMBER); }

```

```

<MAP> Palette { return(PALETTE); }
<MAP> \{      { return(LEFT_BRACE); }
<MAP> \}      { return(RIGHT_BRACE); }
<MAP> Range   { return(RANGE); }
<MAP> Line    { return(LINE); }

```

```

<VIDEO> Type   { return(TYPE); }
<VIDEO> MONO   { return(FORMAT_MONO); }
<VIDEO> RGB    { return(FORMAT_RGB); }
<VIDEO> YUV    { return(FORMAT_YUV); }
<VIDEO> Rate   { return(RATE); }
<VIDEO> Disk   { return(DISK); }
<VIDEO> Gamma  { return(GAMMA); }
<VIDEO> Negative { return(NEGATIVE); }

```

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<VIDEO> Path { return(PATH); }  
<VIDEO> Files { return(FILE); }  
<VIDEO> Transform { return(TRANSFORM); }  
<VIDEO> None { return(TRANSFORM\_NONE); }  
<VIDEO> Wavelet { return(TRANSFORM\_WAVE); }  
<VIDEO> Start { return(START); }  
<VIDEO> End { return(END); }  
<VIDEO> Length { return(LEN); }  
<VIDEO> Dimensions { return(DIM); }  
<VIDEO> Header { return(HEADER); }  
<VIDEO> Offsets { return(OFFSETS); }  
<VIDEO> Size { return(SIZE); }  
<VIDEO> Precision { return(PRECISION); }  
<VIDEO> Yes { yylval.bool=True; return(BOOLEAN); }  
<VIDEO> No { yylval.bool=False; return(BOOLEAN); }

<BATCH> Load { return(Load); }  
<BATCH> Save { return(SAVE); }  
<BATCH> SaveAbekus { return(SAVE\_ABEKUS); }  
<BATCH> Compare { return(COMPARE); }  
<BATCH> Drop { return(DROP); }  
<BATCH> ImportKLICS { return(IMPORT\_KLICS); }  
<BATCH> Transform { BEGIN BATCH\_TRANS; return(TRANSFORM); }  
<BATCH> Compress { BEGIN BATCH\_COMP; return(COMPRESS); }  
<BATCH> Xwave { return(XWAVE); }  
<BATCH> Shell { return(SHELL); }  
<BATCH> Copy { return(COPY); }  
<BATCH> Direct { return(DIRECT\_COPY); }  
<BATCH> Diff { return(DIFF); }  
<BATCH> LPFzero { return(LPF\_WIPE); }  
<BATCH> LPFonly { return(LPF\_ONLY); }  
<BATCH> RGB-YUV { return(RGB\_YUV); }

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< BATCH > Gamma { return(GAMMA); }

< BATCH\_COMP > VideoName { return(VIDEO\_NAME); }

< BATCH\_COMP > Stats { return(STATS\_NAME); }

< BATCH\_COMP > Binary { return(BIN\_NAME); }

< BATCH\_COMP > Yes { yylval.bool = True; return(BOOLEAN); }

< BATCH\_COMP > No { yylval.bool = False; return(BOOLEAN); }

< BATCH\_COMP > Still { return(STILL\_MODE); }

< BATCH\_COMP > Video { return(VIDEO\_MODE); }

< BATCH\_COMP > AutoQuant { return(AUTO\_Q); }

< BATCH\_COMP > QuantConst { return(QUANT\_CONST); }

< BATCH\_COMP > ThreshConst { return(THRESH\_CONST); }

< BATCH\_COMP > BaseFactor { return(BASE\_FACTOR); }

< BATCH\_COMP > DiagFactor { return(DIAG\_FACTOR); }

< BATCH\_COMP > ChromeFactor { return(CHROME\_FACTOR); }

< BATCH\_COMP > Decision { return(DECISION); }

< BATCH\_COMP > Feedback { return(FEEDBACK); }

< BATCH\_COMP > Maximum { return(DEC\_MAX); }

< BATCH\_COMP > SigmaAbs { return(DEC\_SIGABS); }

< BATCH\_COMP > SigmaSqr { return(DEC\_SIGSQR); }

< BATCH\_COMP > Filter { return(FILTER); }

< BATCH\_COMP > None { return(FLT\_NONE); }

< BATCH\_COMP > Exp { return(FLT\_EXP); }

< BATCH\_COMP > CmpConst { return(CMP\_CONST); }

< BATCH\_COMP > FrameRate { return(FPS); }

< BATCH\_COMP > Bitrate { return(BITRATE); }

< BATCH\_COMP > Buffer { return(BUFFER); }

< BATCH\_COMP > \{ { return(LEFT\_BRACE); }

< BATCH\_COMP > \} { END; BEGIN BATCH;

return(RIGHT\_BRACE); }

< BATCH\_TRANS > VideoName { return(VIDEO\_NAME); }

```

< BATCH_TRANS > Direction    { return(DIRECTION); }
< BATCH_TRANS > Space { return(SPACE); }
< BATCH_TRANS > Precision    { return(PRECISION); }
< BATCH_TRANS > Yes          { yyival.bool=True; return(BOOLEAN); }
< BATCH_TRANS > No           { yyival.bool=False; return(BOOLEAN); }
< BATCH_TRANS > \{           { return(LEFT_BRACE); }
< BATCH_TRANS > \}           { END; BEGIN BATCH; return(RIGHT_BRACE); }

```

```
[. \t\n]      { ; }
```

% %

```
yywrap() { return(1); }
```

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source/Transform.h

```
typedef struct {  
    Video src;  
    char  name[STRLEN], src_name[STRLEN];  
    int   space[2], precision;  
    Boolean dirn;  
} TransCtrlRec, *TransCtrl;
```

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source/Video.h

```
typedef struct {  
    char  names[4][STRLEN];  
} AbekusCtrlRec, *AbekusCtrl;
```

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## source/makefile

```

# Xwave Makefile
#
CFLAGS = -O -I../include
LIBS   = -lXaw -lXmu -lXt -lXext -lX11 -lm -ll -L/usr/openwin/lib

KEEP_STATE:
.SUFFIXES: .c .o

xwaveSRC = Select.c Convert.c xwave.c InitMain.c Pop2.c Video2.c Malloc.c
InitFrame.c \
    Frame.c Transform.c Convolve3.c Update.c Image.c Menu.c
PullRightMenu.c \
    NameButton.c SmeBSBpr.c Process.c Lex.c Gram.c Parse.c Color.c \
    Bits.c Storage.c Copy.c Message.c Palette.c ImportKlics.c Icon3.c Klics5.c
\
    KlicsSA.c KlicsTestSA.c ImportKlicsSA.c ImpKlicsTestSA.c

objDIR = ../$(ARCH)

xwaveOBJ = $(xwaveSRC:%.c=$(objDIR)/%.o)

$(objDIR)/xwave: $(xwaveOBJ)
    gcc -o $@ $(xwaveOBJ) $(LIBS) $(CFLAGS)
    echo .....

$(xwaveOBJ): $(@F:.o=.c) ../include/xwave.h
    gcc -c $(@F:.o=.c) $(CFLAGS) -o $@

Lex.c: Gram.c Lex.l

```

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```
lex Lex.l
```

```
mv lex.yy.c Lex.c
```

```
Gram.c: Gram.y
```

```
bison -dlt Gram.y
```

```
mv $(@F:.c=.tab.h) ../include/Gram.h
```

```
mv $(@F:.c=.tab.c) Gram.c
```



include/Bits.h

#ifndef \_Bits\_h

#define \_Bits\_h

```
typedef struct {
    unsigned char buf;
    int bufsize;
    FILE *fp;
} BitsRec, *Bits;
```

#endif

include/DTheader.h

```
typedef struct DTheader {
    char file_id[8];          /* "DT-IMAGE" */
    char struct_id;           /* 1 */
    char prod_id;             /* 4 */
    char util_id;             /* 1 */
    char board_id;            /* 2 */
    char create_time[9]; /* [0-1]year, [2]month, [3]dayofmonth, [4]dayofweek,
[5]hour, [6]min, [7]sec, [8]sec/100 */
    char mod_time[9];         /* as create_time */
    char datum;               /* 1 */
    char datasize[4];         /* 1024?? */
    char file_struct;         /* 1 */
    char datatype;            /* 1 */
    char compress;            /* 0 */
    char store;               /* 1 */
    char aspect[2];           /* 4, 3 */
    char bpp;                 /* 8 */
    char spatial;             /* 1 */
    char width[2];            /* 512 */
    char height[2];           /* 512 */
    char full_width[2];       /* 512 */
    char full_height[2];      /* 512 */
    char unused1[45];
    char comment[160];
    char unused2[256];
} DTheader;
```

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include/icon.h

```
typedef      enum {  
    FW_label, FW_icon, FW_command, FW_text, FW_button, FW_icon_button,  
    FW_view, FW_toggle,  
    FW_yn,  
    FW_up, FW_down, FW_integer,  
    FW_scroll, FW_float,  
    FW_form,  
} FormWidgetType;
```

```
typedef      enum {  
    SW_below, SW_over, SW_top, SW_menu,  
} ShellWidgetType;
```

```
typedef      struct {  
    String name;  
    String contents;  
    int      fromHoriz, fromVert;  
    FormWidgetType type;  
    String hook;  
} FormItem;
```

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include/Image.h

/\*

• \$XConsortium: Image.h,v 1.24 89/07/21 01:48:51 kit Exp \$

\*/

.....

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```
...../

#ifndef _XawImage_h
```

```
#define _XawImage_h
```

```
/*.....*/
```

```
*
```

```
* Image Widget
```

```
*
```

```
.....*/
```

```
#include <X11/Xaw/Simple.h>
```

```
#include <X11/Xmu/Converters.h>
```

```
/* Resources:
```

| Name              | Class             | RepType        | Default Value       |
|-------------------|-------------------|----------------|---------------------|
| border            | BorderColor       | Pixel          | XtDefaultForeground |
| borderWidth       | BorderWidth       | Dimension      | 1                   |
| cursor            | Cursor            | Cursor         | None                |
| destroyCallback   | Callback          | XtCallbackList | NULL                |
| insensitiveBorder | Insensitive       | Pixmap         | Gray                |
| mappedWhenManaged | MappedWhenManaged | Boolean        | True                |
| sensitive         | Sensitive         | Boolean        | True                |
| bitmap            | Bitmap            | Pixmap         | NULL                |
| callback          | Callback          | XtCallbackList | NULL                |
| x                 | Position          | Position       | 0                   |

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```

y          Position      Position      0

*/

#define XtNbitmap  "bitmap"

#define XtCBitmap  "Bitmap"

/* Class record constants */

extern WidgetClass imageWidgetClass;

typedef struct _ImageClassRec *ImageWidgetClass;
typedef struct _ImageRec      *ImageWidget;

#endif /* _XawImage_h */
/* DON'T ADD STUFF AFTER THIS #endif */
```

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**include/ImageHeader.h**

```

/* Author: Philip R. Thompson
 * Address: phils@athena.mit.edu, 9-526
 * Note: size of header should be 1024 (1K) bytes.
 * $Header: ImageHeader.h,v 1.2 89/02/13 09:01:36 phils Locked $
 * $Date: 89/02/13 09:01:36 $
 * $Source: /mit/phils/utils/RCS/ImageHeader.h,v $
 */

#define IMAGE_VERSION 3

typedef struct ImageHeader {
    char file_version[8]; /* header version */
    char header_size[8]; /* Size of file header in bytes */
    char image_width[8]; /* Width of the raster image */
    char image_height[8]; /* Height of the raster image */
    char num_colors[8]; /* Actual number of entries in c_map */
    char num_channels[8]; /* 0 or 1 = pixmap, 3 = RG&B buffers */
    char num_pictures[8]; /* Number of pictures in file */
    char alpha_channel[4]; /* Alpha channel flag */
    char runlength[4]; /* Runlength encoded flag */
    char author[48]; /* Name of who made it */
    char date[32]; /* Date and time image was made */
    char program[16]; /* Program that created this file */
    char comment[96]; /* other viewing info. for this image */
    unsigned char c_map[256][3]; /* RGB values of the pixmap indices */
} ImageHeader;

/* Note:
 * - All data is in char's in order to maintain easily portability

```

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- \* across machines and some human readability.
- \* - Images may be stored as pixmaps or in separate channels, such as
- \* red, green, blue data.
- \* - An optional alpha channel is separate and is found after every
- \* num\_channels of data.
- \* - Pixmaps, red, green, blue, alpha and other channel data are stored
- \* sequentially after the header.
- \* - If num\_channels = 1 or 0, a pixmap is assumed and up to num\_colors
- \* of colormap in the header are used.
- \* /

/\* end ImageHeader.h \*/



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include/ImageP.h

/\*

\* SXConsortium: ImageP.h, v 1.24 89/06/08 18:05:01 swick Exp \$

\*/

/\*.....

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.....\*/

/\*

\* ImageP.h - Private definitions for Image widget

\*

\*/

#ifndef \_XawImageP\_h

#define \_XawImageP\_h

.....

\*

\* Image Widget Private Data

\*

.....\*/

#include "../include/Image.h"

#include <X11/Xaw/SimpleP.h>

/\* New fields for the Image widget class record \*/

typedef struct {int foo;} ImageClassPart;

/\* Full class record declaration \*/

```
typedef struct _ImageClassRec {
    CoreClassPart   core_class;
    SimpleClassPart simple_class;
```

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```

    ImageClassPart  image_class;
} ImageClassRec;

```

```

extern ImageClassRec imageClassRec;

```

```

/* New fields for the Image widget record */

```

```

typedef struct {

```

```

    /* resources */

```

```

        Pixmap      pixmap;

```

```

        XtCallbackList  callbacks;

```

```

    /* private state */

```

```

        Dimension    map_width, map_height;

```

```

} ImagePart;

```

```

/*****

```

```

 *

```

```

 * Full instance record declaration

```

```

 *

```

```

*****/

```

```

typedef struct _ImageRec {

```

```

    CorePart  core;

```

```

    SimplePart  simple;

```

```

    ImagePart  image;

```

```

} ImageRec;

```

```

#endif /* _XawImageP_h */

```

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**include/Message.h**

```
typedef      struct {  
    Widget      shell, widget; /* shell and text widgets (NULL if not created */  
    XawTextBlock info; /* Display text */  
    int    size, rows, cols; /* Size of buffer (info.ptr) & dimensions of display */  
    XawTextEditType edit; /* edit type */  
    Boolean    own_text; /* text is owned by message? */  
} MessageRec, *Message;
```

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include/Palette.h

#define PalettePath "."

#define PaletteExt ".pal"

```
typedef struct _MapRec {
    int    start, finish, m, c;
    struct _MapRec  *next;
} MapRec, *Map;
```

```
typedef struct _PaletteRec {
    char  name[STRLEN];
    Map  mappings;
    struct _PaletteRec  *next;
} PaletteRec, *Palette;
```

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include/PullRightMenu.h

/\*

\* SXConsortium: PullRightMenu.h,v 1.17 89/12/11 15:01:55 kit Exp \$

\*

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\*

\*/

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/\*

\* PullRightMenu.h - Public Header file for PullRightMenu widget.

\*

\* This is the public header file for the Athena PullRightMenu widget.

\* It is intended to provide one pane pulldown and popup menus within

\* the framework of the X Toolkit. As the name implies it is a first and

\* by no means complete implementation of menu code. It does not attempt to

\* fill the needs of all applications, but does allow a resource oriented

\* interface to menus.

\*

\*/

#ifndef \_PullRightMenu\_h

#define \_PullRightMenu\_h

#include &lt;X11/Shell.h&gt;

#include &lt;X11/Xmu/Converters.h&gt;

/\*\*\*\*\*

\*

\* PullRightMenu widget

\*

\*\*\*\*\*/

/\* PullRightMenu Resources:

| Name             | Class            | RepType | Default Value       |
|------------------|------------------|---------|---------------------|
| background       | Background       | Pixel   | XtDefaultBackground |
| backgroundPixmap | BackgroundPixmap | Pixmap  | None                |
| borderColor      | BorderColor      | Pixel   | XtDefaultForeground |
| borderPixmap     | BorderPixmap     | Pixmap  | None                |

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|                   |                   |           |                      |
|-------------------|-------------------|-----------|----------------------|
| borderWidth       | BorderWidth       | Dimension | 1                    |
| bottomMargin      | VerticalMargins   | Dimension | VerticalSpace        |
| columnWidth       | ColumnWidth       | Dimension | Width of widest text |
| cursor            | Cursor            | Cursor    | None                 |
| destroyCallback   | Callback          | Pointer   | NULL                 |
| height            | Height            | Dimension | 0                    |
| label             | Label             | String    | NULL (No label)      |
| labelClass        | LabelClass        | Pointer   | smeBSBObjectClass    |
| mappedWhenManaged | MappedWhenManaged | Boolean   | True                 |
| rowHeight         | RowHeight         | Dimension | Height of Font       |
| sensitive         | Sensitive         | Boolean   | True                 |
| topMargin         | VerticalMargins   | Dimension | VerticalSpace        |
| width             | Width             | Dimension | 0                    |
| button            | Widget            | Widget    | NULL                 |
| x                 | Position          | Position  | 0                    |
| y                 | Position          | Position  | 0                    |

\*/

```
typedef struct _PullRightMenuClassRec* PullRightMenuWidgetClass;
typedef struct _PullRightMenuRec* PullRightMenuWidget;
```

```
extern WidgetClass pullRightMenuWidgetClass;
```

```
#define XtNcursor "cursor"
#define XtNbottomMargin "bottomMargin"
#define XtNcolumnWidth "columnWidth"
#define XtNlabelClass "labelClass"
#define XtNmenuOnScreen "menuOnScreen"
#define XtNpopupOnEntry "popupOnEntry"
#define XtNrowHeight "rowHeight"
#define XtNtopMargin "topMargin"
```



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```
#define XtNbutton    "button"
```

```
#define XtCColumnWidth "ColumnWidth"
```

```
#define XtCLabelClass "LabelClass"
```

```
#define XtCMenuOnScreen "MenuOnScreen"
```

```
#define XtCPopupOnEntry "PopupOnEntry"
```

```
#define XtCRowHeight "RowHeight"
```

```
#define XtCVerticalMargins "VerticalMargins"
```

```
#define      XtCWidget    "Widget"
```

```
/*.....
 *
 * Public Functions.
 *
 *.....*/
```

```
/*      Function Name: XawPullRightMenuAddGlobalActions
 *      Description: adds the global actions to the simple menu widget.
 *      Arguments: app_con - the appcontext.
 *      Returns: none.
 */
```

```
void
```

```
XawpullRightMenuAddGlobalActions(/* app_con */);
```

```
/*
```

```
XtAppContext app_con;
```

```
*/
```

```
#endif /* _PullRightMenu_h */
```

include/SmeBSBpr.h

/\*

\* \$XConsortium: SmeBSB.h,v 1.5 89/12/11 15:20:14 kit Exp \$

\*

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```

/*
 * SmeBSBpr.h - Public Header file for SmeBSB object.
 *
 * This is the public header file for the Athena BSB Sme object.
 * It is intended to be used with the simple inmenu widget. This object
 * provides bitmap - string - bitmap style entries.
 *
 */

```

```

#ifndef _SmeBSBpr_h

```

```

#define _SmeBSBpr_h

```

```

#include <X11/Xmu/Converters.h>

```

```

#include <X11/Xaw/Sme.h>

```

```

/*****
 *
 * SmeBSBpr object
 *
 *****/

```

```

/* BSB pull-right Menu Entry Resources:

```

| Name            | Class      | RepType       | Default Value       |
|-----------------|------------|---------------|---------------------|
| callback        | Callback   | Callback      | NULL                |
| destroyCallback | Callback   | Pointer       | NULL                |
| font            | Font       | XFontStruct * | XtDefaultFont       |
| foreground      | Foreground | Pixel         | XtDefaultForeground |
| height          | Height     | Dimension     | 0                   |
| label           | Label      | String        | Name of entry       |

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|             |                   |           |        |
|-------------|-------------------|-----------|--------|
| leftBitmap  | LeftBitmap        | Pixmap    | None   |
| leftMargin  | HorizontalMargins | Dimension | 4      |
| rightBitmap | RightBitmap       | Pixmap    | None   |
| rightMargin | HorizontalMargins | Dimension | 4      |
| sensitive   | Sensitive         | Boolean   | True   |
| vertSpace   | VertSpace         | int       | 25     |
| width       | Width             | Dimension | 0      |
| x           | Position          | Position  | 0n     |
| y           | Position          | Position  | 0      |
| menuName    | MenuName          | String    | "menu" |

\*/

```
typedef struct _SmeBSBprClassRec    *SmeBSBprObjectClass;
typedef struct _SmeBSBprRec        *SmeBSBprObject;
```

```
extern WidgetClass smeBSBprObjectClass;
```

```
#define XtNleftBitmap "leftBitmap"
#define XtNleftMargin "leftMargin"
#define XtNrightBitmap "rightBitmap"
#define XtNrightMargin "rightMargin"
#define XtNvertSpace "vertSpace"
#define XtNmenuName "menuName"

#define XtCLeftBitmap "LeftBitmap"
#define XtCHorizontalMargins "HorizontalMargins"
#define XtCRightBitmap "RightBitmap"
#define XtCVertSpace "VertSpace"
#define XtCMenuName "MenuName"

#endif /* _SmeBSBpr_h */
```

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include/SmeBSBP.h

/\*

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- \*
- \* Author: Chris D. Peterson, MIT X Consortium

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\*/

/\*

\* SmeP.h - Private definitions for Sme object

\*

\*/

#ifndef \_XawSmeBSBP\_h

#define \_XawSmeBSBP\_h

/\*\*\*\*\*

\*

\* Sme Object Private Data

\*

\*\*\*\*\*/

#include &lt;X11/Xaw/SmeP.h&gt;

#include "../include/SmeBSBpr.h"

/\*\*\*\*\*

\*

\* New fields for the Sme Object class record.

\*

\*\*\*\*\*/

typedef struct \_SmeBSBprClassPart {

XtPointer extension;

} SmeBSBprClassPart;

/\* Full class record declaration \*/

typedef struct \_SmeBSBprClassRec {

RectObjClassPart rect\_class;

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```

SmeClassPart    sme_class;
SmeBSBprClassPart sme_bsb_class;
} SmeBSBprClassRec;

extern SmeBSBprClassRec smeBSBprClassRec;

/* New fields for the Sme Object record */
typedef struct {
    /* resources */
    String label;          /* The entry label. */
    int vert_space;        /* extra vert space to leave, as a percentage
                           of the font height of the label. */
    Pixmap left_bitmap, right_bitmap; /* bitmaps to show. */
    Dimension left_margin, right_margin; /* left and right margins. */
    Pixel foreground;      /* foreground color. */
    XFontStruct * font;    /* The font to show label in. */
    XJustify justify;      /* Justification for the label. */
    String menu_name;      /* Popup menu name */

    /* private resources. */

    Boolean set_values_area_cleared; /* Remember if we need to unhighlight. */
    GC norm_gc;                      /* normal color gc. */
    GC rev_gc;                       /* reverse color gc. */
    GC norm_gray_gc;                 /* Normal color (grayed out) gc. */
    GC invert_gc;                   /* gc for flipping colors. */

    Dimension left_bitmap_width; /* size of each bitmap. */
    Dimension left_bitmap_height;
    Dimension right_bitmap_width;
    Dimension right_bitmap_height;

```

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```
} SmeBSBprPart;
```

```
/* .....  
 *  
 * Full instance record declaration  
 *  
 .....*/
```

```
typedef struct _SmeBSBprRec {  
    ObjectPart    object;  
    RectObjPart   rectangle;  
    SmePart       sme;  
    SmeBSBprPart  sme_bsb;  
} SmeBSBprRec;
```

```
/* .....  
 *  
 * Private declarations.  
 *  
 .....*/
```

```
#endif /* _XawSmeBSBPpr_h */
```



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include/xwave.h

```
#include <X11/Xlib.h>
#include <X11/Xutil.h>
#include <X11/Xatom.h>
#include <X11/Xaw/Cardinals.h>
#include <X11/StringDefs.h>
#include <X11/Xmu/Xmu.h>
#include <X11/Xaw/Command.h>
#include <X11/Xaw/List.h>
#include <X11/Xaw/Box.h>
#include <X11/Xaw/Form.h>
#include <X11/Xaw/Scrollbar.h>
#include <X11/Xaw/Viewport.h>
#include <X11/Xaw/AsciiText.h>
#include <X11/Xaw/Dialog.h>
#include <X11/Xaw/MenuButton.h>
#include <X11/Xaw/SimpleMenu.h>
#include <X11/Xaw/SmcBSB.h>
#include <X11/Xaw/Toggle.h>
#include "SmcBSBpr.h"
#include "PullRightMenu.h"
#include <X11/Shell.h>
#include <X11/cursorfont.h>
#define STRLEN 100
#define NAME_LEN 20
#include "Image.h"
#include "Message.h"
#include <dirent.h>
#include <math.h>
```

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```
#include    <stdio.h>
#include    "Palette.h"
#include    "Icon.h"

#define     PLOT_DIR    "graphs"
#define     PLOT_EXT    ".plot"
#define     ELLA_IN_DIR    "."
#define     ELLA_IN_EXT    ".eli"
#define     ELLA_OUT_DIR    "."
#define     ELLA_OUT_EXT    ".elo"
#define     VID_DIR    "videos"
#define     VID_EXT    ".vid"
#define     IMAGE_DIR    "images"
#define     BATCH_DIR    "batch"
#define     BATCH_EXT    ".bat"
#define     KLICS_DIR    "import"
#define     KLICS_EXT    ".klics"
#define     KLICS_SA_DIR    "import"
#define     KLICS_SA_EXT    ".klicsSA"
```

```
typedef enum {
    TRANS_None, TRANS_Wave,
} TransType;
```

```
typedef    enum {
    MONO, RGB, YUV,
} VideoFormat;
```

```
extern String ChannelName[3][4];
```

```
#define     negif(bool,value)    ((bool)?-(value):(value))
```

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```
typedef struct {
    String name;
    Pixmap pixmap;
    unsigned int height, width;
} IconRec, *Icon;
```

```
typedef void (*Proc)();
typedef String *(*ListProc)();
typedef Boolean (*BoolProc)();
```

```
typedef struct {
    String name;
    WidgetClass widgetClass;
    String label;
    String hook; /* menuName for smeBSBprObjectClass */
} MenuItem;
```

```
typedef struct {
    String name, button;
    ListProc list_proc;
    String action_name;
    Proc action_proc;
    caddr_t action_closure;
} SelectItem, *Selection;
```

```
typedef struct {
    TransType type;
    int space[2];
    Boolean dirn;
} WaveletTrans;
```

```
typedef union {
```

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```

    TransType    type;
    WaveletTrans    wavelet;
} VideoTrans;

```

```

typedef    struct _VideoRec    {
    char    name[STRLEN];                /* Name of this video name.vid */
    char    path[STRLEN];                /* Path to frame file(s) */
    char    files[STRLEN];                /* Name of frames files001 if not name */
    VideoFormat type;                    /* Type of video (MONO,RGB,YUV) */
    Boolean    disk; /* Frames reside on disk rather than in memory */
    Boolean    gamma;                    /* Gamma corrected flag */
    Boolean    negative;                /* Load negative values in data */
    int    rate;                        /* Frames per second */
    int    start;                      /* Starting frame number */
    int    size[3]; /* Dimensions of video after extraction x, y and z */
    int    UVsample[2];                /* Chrominance sub-sampling x and y */
    int    offset;                    /* Header length */
    int    cols, rows;                /* Dimensions of video as stored */
    int    x_offset, y_offset; /* Offset of extracted video in stored */
    VideoTrans    trans;                /* Transform technique used */
    int    precision;                /* Storage precision above 8 bits */
    short    **data[3];                /* Image data channels */
    struct _VideoRec    *next;        /* Next video in list */
} VideoRec, *Video;

```

```

typedef    struct {
    Video video;
    char    name[STRLEN];
} VideoCtrlRec, *VideoCtrl;

```

```

typedef    struct _PointRec    {
    int    location[2];

```

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```
int    usage;
struct _PointRec    *next;
} PointRec, *Point;

typedef    struct _FrameRec    {
    Widget    shell, image_widget, point_merge_widget;
    Video video;
    int    zoom, frame, channel, palette;
    Boolean    point_switch, point_merge;
    Point point;
    Message    msg;
    struct _FrameRec    *next;
} FrameRec, *Frame;
```

```
#define    NO_CMAPS 6
```

```
typedef    struct _BatchRec    {
    Proc    proc;
    caddr_t    closure, call_data;
    struct _BatchRec    *next;
} BatchRec, *Batch;
```

```
typedef    struct {
    char    home[STRLEN];
    XtAppContext    app_con;
    Widget    toplevel;
    int    no_icons;
    Icon    icons;
    Video videos;
    Frame frames;
    Point points;
    Palette    palettes;
```

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```
int    no_pals;
String parse_file;
String parse_token;
FILE   *parse_fp;
XVisualInfo *visinfo;
int     levels, rgb_levels, yuv_levels[3];
Colormap  cmaps[NO_CMAPS];
String batch;
Batch batch_list;
Boolean  debug;
int     dither[16][16];
} GlobalRec, *Global;
```

```
typedef struct {
    Widget    widgets[3];
    int       max, min, *value;
    String format;
} NumInputRec, *NumInput;
```

```
typedef struct {
    Widget    widgets[2];
    double    max, min, *value;
    String format;
} FloatInputRec, *FloatInput;
```

```
extern Global    global;
```

```
/* InitFrame.c */
```

```
extern Video FindVideo();
```

```
/* Pop2.c */
```

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```
extern void    NAO;
extern Widget  FindWidget();
extern void    Destroy();
extern void    Free();
```

```
/* Storage.c */
```

```
extern void    NewFrame();
extern void    GetFrame();
extern void    SaveFrame();
extern void    FreeFrame();
extern void    SaveHeader();
extern Video   CopyHeader();
```

```
/* Message.c */
```

```
extern void    TextSize();
extern Message NewMessage();
extern void    MessageWindow();
extern void    CloseMessage();
extern void    Mprintf();
extern void    Dprintf();
extern void    Eprintf();
extern void    Mflush();
```

```
/* Icon3.c */
```

```
extern void    FillForm();
extern void    FillMenu();
extern Widget  ShellWidget();
extern Widget  FormatWidget();
extern void    SimpleMenu();
```

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```
extern int    TextWidth();
extern Icon   FindIcon();
extern void   NumIncDec();
extern void   FloatIncDec();
extern void   ChangeYN();
extern XFontStruct *FindFont();
```



DATA COMPRESSION AND DECOMPRESSION  
GREGORY KNOWLES AND ADRIAN S. LEWIS  
M-2357 US  
APPENDIX B-1

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```

MAC ADDR_COUNTER_COL = (bool:ck,1_reset:reset,STRING[ysize]bit:block_cnt_length)
->
(l_col,bool):
BEGIN
MAKE BASE_COUNTER_COL:base_counter_col.
JOIN (ck,reset:block_cnt_length) ->base_counter_col.

OUTPUT (base_counter_col[1], CASE base_counter_col[2]
      OF
      count_carry:1
      ELSE 1
      ESAC)

END.

MAC ADDR_COUNTER_ROW = (bool:ck,1_reset:reset,STRING[ysize]bit:block_cnt_length,bool:col_carry)
->
(l_row,bool):
BEGIN
MAKE BASE_COUNTER_ROW:base_counter_row.
JOIN (ck,reset,col_carry:block_cnt_length,CASE col_carry #type conversion#
      OF 1:count_carry
      ELSE count_reset
      ESAC) ->base_counter_row.

OUTPUT (base_counter_row[1], CASE base_counter_row[2]
      OF count_carry:1
      ELSE 1
      ESAC)

END.

#the string base address calculators#

```

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```
MAC NOMULT_MAC_READ = (bool:ck,l_reset:reset,bool:col_end,l_mux4:mux_control,STRING[17]bit:incr,
  STRING[17]bit:oct_add_factor, STRING[19]bit:base_u base_v)
->
```

```
  STRING[19]bit:
```

```
  BEGIN
```

```
  MAKE ADD_US_ACTEL[19,17]:add,
```

```
  MUX_2[STRING[17]bit]:mux.
```

```
  LET
```

```
    next_addr = MUX_4[STRING[19]bit](add[2..20],ZERO[19]b'0',base_u,base_v,mux_control),
    dff = DFF_NO_LOAD[STRING[19]bit](ck,reset,next_addr,b'000000000000000000000000').
```

```
  JOIN (dff,mux,b'1) ->add,
    (incr,oct_add_factor,CASE col_end
```

```
    OF t:right
```

```
    ELSE left
```

```
    ESAC)
```

```
->mux.
```

```
  OUTPUT dff
```

```
  END.
```

```
  MAC S_SPA =(STRING[19]bit:in)
```

```
->
```

```
    (flag,l_sparc_addr):BIOP TRANSFORM_US.
```

```
  MAC SPA_S =(l_sparc_addr:in)
```

```
->
```

```
    (flag,STRING[19]bit):BIOP TRANSFORM_US.
```

```
  MAC SPARC_ADDR= (bool:ck,l_reset:reset,bool:col_end,l_mux4:mux_control[2]l_sparc_addr:oct_add_factor,
```

```

STRING[19]bit base_u base_v)
->
    l_sparc_addr;

BEGIN
LET out=NOMULT_MAC_READ(ck,reset,col_end,mux_control,(SPA_S oct_add_factor[1])[2][3..19].
    (SPA_S oct_add_factor[2])[2][3..19]base_u base_v).
OUTPUT (S_SPA out)[2]
END.

#-----#

#the read and write address generator,input the initial image & block sizes for oct/0 at that channel#
FN ADDR_GEN_NOSCRATCH= (bool:ck,l_reset:reset,l_direction:direction,l_channel:channel,
    STRING[9]bit x_p_1,STRING[11]bit x3_p_1,STRING[12]bit x7_p_1,
    STRING [ysize]bit:octave_row_length,STRING [xsize]bit:octave_col_length,l_reset:octave_reset,
    l_octave:octave,bool:y_done,bool:uv_done,l_bad:octave_finished,STRING [19]bit:base_u base_v)

->
    ((l_input_mux,l_sparcport,l_dwtport#dwt#),l_bad#IDWT data valid#l_load#read_valid#
        ,l_count_control#row read col read#,(l_col,l_count_control)#addr_col_read#);
#the current octave and when the block finishes the 3 octave transform#
BEGIN
# ADDR_COUNTER_ROW:addr_row_write,#
# ADDR_COUNTER_COL:addr_col_write,#
MAKE ROW_COUNT_CARRY:addr_row_read,
COL_COUNT: addr_col_read,
SPARC_ADDR:write_addr_read_addr,
MEM_CONTROL_NOSCRATCH:mem_control,

```

#write begins #

JKFF:zero\_hh\_bool read\_done\_bool.

LET mem\_sel

= CASE oclave  
 OF ocl/0:uno,  
 ocl/1:dos,  
 ocl/2:tres,  
 ocl/3:quatro  
 ESAC.

sparc\_add\_1

= MUX\_4(!sparc\_add1)(  
 (addr/1),  
 (addr/2),  
 (addr/4),  
 (addr/8),  
 mem\_sel).

sparc\_add\_2\_y

= MUX\_4(STRING[12]b1)(  
 (b"0000000000001"),  
 (b"000" CONC x\_p\_1[1..7] CONC b"10"),  
 (b"0" CONC x3\_p\_1[1..8] CONC b"100"),  
 (x7\_p\_1[1..8] CONC b"1000"),  
 mem\_sel).

sparc\_add\_2\_uv

= MUX\_4(STRING[12]b1)(  
 (b"0000000000001"),  
 (b"0000" CONC x\_p\_1[1..5] CONC b"10"),  
 (b"00" CONC x3\_p\_1[1..7] CONC b"100"),  
 (b"0" CONC x7\_p\_1[1..7] CONC b"1000"),  
 mem\_sel).

sparc\_add\_2

= MUX\_2(STRING[12]b1)(sparc\_add\_2\_y, sparc\_add\_2\_uv, CASE channel

OF y:left  
ELSE right  
ESAC).

sparc\_oel\_add\_factor = (sparc\_add\_1.(S\_SPA( b'00000000' CONC sparc\_add\_2))[2]).

#signals when write must start delayed 1 tu for use in zero\_hh#

addr\_col\_read\_flag = CASE addr\_col\_read[2]#decode to bool#  
OF count\_carry.1  
ELSE 1  
ESAC.

write\_latency = CASE (addr\_row\_read[1], addr\_col\_read[1])  
OF (row/2,col/(conv2d\_latency-1)):1  
ELSE 1  
ESAC.

read\_done = CASE (addr\_row\_read[2], addr\_col\_read\_flag)  
OF (count\_carry.1):1  
ELSE 1  
ESAC. #read input data done#

zero\_hh = CAST(!\_load)(NOT zero\_hh\_bool).

read\_valid = CAST(!\_load)(NOT read\_done\_bool).

start\_write\_col = DFF\_NO\_LOAD(!\_load)[ck,reset,zero\_hh,read], #1 tu after zero\_hh#

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```

read_mux = CASE (y_done,uv_done,oclave_finished,channel)
OF
  ((t,t,write,y))((t,t,write,u):tres, #base_u#
  ((t,t,write,u))((t,t,write,v):qualro, #base_v#
  ((t,bool,write,y):dos #base_y#
ELSE uno
ESAC,

```

```

write_mux = CASE zero_hh
OF write:uno,
      read:
        CASE channel
        OF y:dos, #base_y#
           u:tres, #base_u#
           v:qualro #base_v#
        ESAC
      ESAC.

```

JOIN

#note that all the counters have to be reset at the end of an octave, ie on octave\_finished#

```

(ck,oclave_reset,oclave_col_length) ->addr_col_read, #the row&col counts for the read address#
(ck,oclave_reset,oclave_row_length,addr_col_read[2]) ->addr_row_read,

```

```

(ck,oclave_reset,write_latency,t) ->zero_hh_bool,

```

```

(ck,oclave_reset,read_done,t) ->read_done_bool,

```

#w&amp;r addresses for sparc mem#

```

(ck,reset,PDF1{bool,conv2d_latency-1})(ck,reset,addr_col_read_flag,0),write_mux,sparc_oct_add_factor,base_u,base_v)
->write_addr,

```

```

(ck,reset,addr_col_read_flag,read_mux,sparc_oct_add_factor,base_u,base_v) ->read_addr.

(ck,reset,direction,channel,oclave,write_addr,read_addr,zero_hh)->mem_control.

OUTPUT( mem_control,zero_hh, read_valid,addr_row_read[2],addr_col_read)
END.
#the basic 2d convolver for transform, rows first then cols.#
FN CONV_2D = (bool:ck,t_reset:reset,t_input:in,t_direction:direction,[4]t_scratch:pdcl,
t_reset:conv_reset,t_count_control:row_flag,(t_col,t_count_control):addr_col_read)
->
(t_input,t_memport,t_count_control,t_count_control,t_count_control):
#forward direction outputs in row form #
# HH HG HH HG ..... #
# HG GG HG GG ..... #
# HH HG HH HG ..... #
# HG GG HG GG ..... #
#the inverse convolver returns the raster scan format output data#
#the convolver automatically returns a 3 octave transform#

BEGIN
  FN CH_PORT = ([4]t_scratch,t_col),t_col)
  ->
    t_memport:REFORM.

  MAKE CONV_ROW:conv_row,
    CONV_COL:conv_col.

  LET

```



```

row_reset = CASE direction
  OF forward:conv_reset,
    inverse:PDF1(l_reset,1)(ck,no_rst,conv_reset,rst)  #pipeline delays in col_conv#
  ESAC,
col_reset = CASE direction
  OF forward:PDF1(l_reset,3)(ck,no_rst,conv_reset,rst).
    inverse:conv_reset  #pipeline delays in row_conv#
  ESAC,

col_flag = DFM(l_count_control)(ck,addr_col_read[2],PDF1(l_count_control,1)(ck,reset,addr_col_read[2],
count_0).CAST(bool,direction),

row_control = DFM(l_count_control)(ck,PDF1(l_count_control,3)(ck,reset,row_flag,count_0),
row_flag, CAST(bool,direction),

direction_sel = CASE direction  #mux control for the in/out data muxes#
  OF forward:left,
    inverse:right
  ESAC,

col_count = MUX_2((l_col,l_count_control))((
  PDF1((l_col,l_count_control),3)(ck,reset,addr_col_read,(col/0,count_rst)),
  addr_col_read,
  direction_sel),

#pipeline delays for the convolver values and input values#
del_conv_col=DFF_NO_LOAD(l_input)(ck,reset,conv_col[1],input/0),

del_conv_row=DFF_NO_LOAD(l_input)(ck,reset,conv_row,input/0),

del_in = DFF_NO_LOAD(l_input)(ck,reset,in,input/0).

```

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JOIN

```
(ck,row_reset,direction,MUX_2(t_input)(del_in,del_conv_col,direction_sel),col_flag) ->conv_row,
(ck,col_reset,direction,MUX_2(t_input)(del_conv_row,del_in,direction_sel),pdel,row_control,col_count) ->conv_col.
```

```
OUTPUT (MUX_2(t_input)(del_conv_col,del_conv_row,direction_sel),CH_PORT(conv_col[2],col_count[1]),row_control,col_count[2],col_flag)
END.
```

# 1d col convolver, with control #

```
FN CONV_COL = (bool:ck,t_reset:reset,t_direction:direction,t_input:in,
[4]t_scratch:pdel,t_count_control:row_flag,
(t_col,t_count_control):col_count)
```

-&gt;

(t\_input,([4]t\_scratch,t\_col));

#input is data in and, pdel, out from line-delay memories#

# out is (G,H), and line delay out port. The row counter is started 1 cycle later to allow for#

#pipeline delay between MULTIPLIER and this unit #

BEGIN

# a %2 line by line resetable counter for the state machines, out-&gt;one on rst#

#carry active on last element of row#

MAC COUNT\_2 = (bool:ck,t\_reset:reset,t\_count\_control:carry)

-&gt;

t\_count\_2:

BEGIN

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```

MAKE DFF_NO_LOAD(l_count_2):countdel.
LET countout= CASE (countdel,carry)
  OF  (one,count_carry):two,
      (two,count_carry):one
  ELSE countdel
  ESAC.
JOIN (ck,reset,countout,one) ->countdel.
OUTPUT countdel
END.

```

```

#the code for the convolver#
MAKE MULT_ADD:mult_add,
[4]DFF1(l_scratch):pdel_in,
[4]DFF1(l_scratch):pdel_out,
COUNT_2:count.

```

```

# now the state machines to control the convolver#
#First the and gates#

```

```

LET
  reset_row=DFF1(l_reset)(ck,reset).      #starts row counter 1 cycle after frame start#
#we want the row counter to be 1 cycle behind the col counter for the delay for the#
#pipelined line delay memory#

```

```

col_carry=DFF_NO_LOAD(l_count_control)(ck,reset,col_count[2],count_rst).

```

```

#these need to be synchronised to keep the row counter aligned with the data stream#
#also the delay on col_count deglitches the col carryout#

```

```

row_control=row_flag.      #signal for row=0,1,2,3, last row, etc#

```

```

andset= (CASE direction
  OF   forward: CASE count
        OF   one: pass,
            two: zero
            ESAC,
        Inverse: CASE count
        OF   one: zero,
            two: pass
            ESAC
        ESAC,

CASE row_control
  OF count_0: zero
  ELSE: pass
  ESAC,

CASE direction
  OF   forward: CASE row_control
        OF count_0: zero
        ELSE: pass
        ESAC,
        Inverse: pass
        ESAC),

#now the add/sub control for the convolver address#
addset= CASE count
  OF one: (add, add, add, sub),
  two: (add, sub, add, add)
  ESAC,

```

```

#now the mux control#
centermuxsel=

CASE direction
OF forward: CASE count
    OF one:(left,right),
       two:(right,left)
    ESAC,
    inverse: CASE count
    OF one:(right,left),
       two:(left,right)
    ESAC

    ESAC,

#the perfect reconstruction output#
#the addmuxsel signal#
muxandsel =

CASE direction
OF forward:(andsel[2],pass,andsel[2]),
   inverse:(pass,andsel[2], CASE row_control
    OF count_1 zero
    ELSE pass
    ESAC)

    ESAC,

muxsel= CASE direction
    OF forward:(uno,

CASE row_control
OF count_0: dos,
   count_carry: tres
    ELSE uno
    ESAC,

CASE row_control
OF count_0: tres,

```

```

count_carry:qualro
ELSE dos
ESAC).

```

```

inverse:( CASE row_control
OF count_0:dos,
count_1:qualro,
count_carry:dos,
count_lim1:res
ELSE dos
ESAC,

```

```

CASE row_control
OF count_0:tres,
count_carry:dos
ELSE uno
ESAC,

```

```

uno)

```

```

ESAC.

```

```

LET

```

```

#ACTEL#

```

```

wr_addr      =DF1(!_col)(ck,DF1(!_col)(ck,col_count{1})),
#need 2 delays between wr and rd addr#
rd_addr=col_count{1}.
#address for line delay memory#

```

```

#join the control signals to the mult_add block#
JOIN  (ck,reset_row,col_carry) ->count,

```

```

(ck,reset,in,andsel,centermuxsel,muxsel,muxandsel,addsel,direction,pdel_out) ->mult_add.

```

```

FOR INT k=1..4 JOIN
    (ck,mult_add[k]) -> pdel_in[k],    #delay to catch the write address#
    (ck,pdel[k])      -> pdel_out[k].    #read delay to match MULT delay#

#ACTEL HACK#
LET gh_select = CASE (direction,DF1(l_count_2)(ck,count))
    OF      (inverse,one)((forward,two):right,
              (inverse,two)((forward,one):left
    ESAC,

gh_out = MUX_2(l_scratch)(pdel_in[4],DF1(l_scratch)(ck,pdel_out[1]),gh_select),
shift_const = CASE direction
    OF inverse: CASE DF1(l_count_control)(ck,row_control)
        OF (count_1 | count_2):shift3
        ELSE shift4
    ESAC,
    forward: shift5
    ESAC.

OUTPUT (ROUND_BITS(gh_out,shift_const),(pdel_in,wr_addr#nd_addr#))    #LOCAMI#
END.
#the 1d convolver, with control and coeff extend#

FN CONV_ROW = (bool:ck,l_reset:reset,l_direction:direction,l_input:in,l_count_control:col_flag)
->
    l_input:
# out is (G,H). The row counter is started 1 cycle later to allow for#
#pipeline delay between MULTIPLIER and this unit #
#the strings give the col & row lengths for this octave#

```

```

BEGIN
    # a %2 line by line reselable counter for the state machines, out->one on rsl#
    MAC COUNT_2 = (bool:ck,l_reset:reset)
    ->
        l_count_2:
        BEGIN
            MAKE DFF_NO_LOAD(l_count_2):countdel.
            LET countout= CASE (countdel)
                OF (one):two,
                   (two):one
                ESAC.
            JOIN (ck,reset,countout,one) ->countdel.
            OUTPUT countdel
            END.

        #the code for the convolver#
        MAKE MULT_ADD:mult_add,
            [4]DFF(l_scratch):pdel,
            COUNT_2:count.

        # now the state machines to control the convolver#
        #First the and gates#

        LET
            reset_col=DF1(l_reset)(ck,reset),      #starts row counter 1 cycle after frame start#
  #makes up for the pipeline delay in MULT#
            #11LATENCY DEOENDENT11#
            col_control=col_flag,                  #lag when col_count=0,1,2,col_length,etc#

```



```

andsel=(CASE direction
OF forward: CASE count
OF one:pass,
two:zero
ESAC,
inverse: CASE count
OF one:zero,
two:pass
ESAC,
ESAC,
CASE col_control
OF count_0:zero
ELSE:pass
ESAC,
CASE direction
OF forward: CASE col_control
OF count_0:zero
ELSE:pass
ESAC,
inverse:pass
ESAC),
#now the add/sub control for the convolver address#
addsel= CASE count
OF one:(add,add,add,sub),
two: (add,sub,add,add)
ESAC,
#now the mux control#

```

```

centermuxsel=
CASE direction
OF
  forward: CASE count
    OF one:(left,right),
       two:(right,left)
    ESAC,
  inverse: CASE count
    OF one:(right,left),
       two:(left,right)
    ESAC,
ESAC,
CASE direction
OF
  forward:(andse[2],pass,andse[2]),
  inverse:(pass,andse[2], CASE col_control
    OF count_1:zero
    ELSE pass
    ESAC)
ESAC,
muxsel= CASE direction
OF
  forward:(uno,
CASE col_control
OF count_0:dos,
   count_carry:tres
ELSE uno
ESAC,
CASE col_control
OF count_0:tres,
   count_carry:quattro
ELSE dos

```

#the addmuxsel signal#

```

muxandse[2] =

```

ESAC).

```
inverse: ( CASE col_control
  OF count_0: dos,
    count_1: quatro,
    count_lm1: tres
  ELSE dos
  ESAC,
```

```
  CASE col_control
  OF count_0: tres,
    count_carry: dos
  ELSE uno
  ESAC,
```

uno)

ESAC.

#join the control signals to the mult\_add block#

```
JOIN (ck,reset_col) -> count,
```

#set up the col counters #

```
(ck,reset,in,andael,centermuxsel,muxsel,muxandsel,addsel,direction,pdel)->mult_add.
```

```
FOR INT j=1..4 JOIN
```

```
(ck,mult_add[j]) -> pdel[j].
```

#pipeline delay for mult-add unit#

#ACTEL HACK#

```
LET gh_select=CASE direction
```

```
  OF inverse: CASE count
```

```
    OF one: left,
```

```

        two: right
        ESAC,
        forward: CASE count
        OF one:right,
        two:left
        ESAC
        ESAC,

        gh_out = MUX_2(l_scratch)(pdel[4].DF1(l_scratch)(ck, pdel[1]).gh_select),

        rb_select= CASE direction
        OF inverse:CASE col_control
        OF (count_2 | count_3).shift3
        ELSE shift4
        ESAC,
        forward: shift5
        ESAC.

        OUTPUT ROUND_BITS(gh_out,rb_select)
        END.

        #some string macros#
        MAC EQ_US = (STRING[INT n]bit: a b)
        ->
        bool: BIOPEQ_US.

        #ACTEL 8 bit comparator macro#
        FN ICMP8 = (STRING[8]bit: a b)
        ->
        bool: EQ_US[8](a,b).

```

```

#.....#
#A set of boolean ,ie gate level counters
#.....#

#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle ,outputs are q and tc (toggle for next counter#
#stage
#.....#

MAC BASIC_COUNT = (bool:ck ,t_reset:reset,bool: tog)
->
[2]bool:

BEGIN
    MAKE DFF_NO_LOAD[bool]:dlat,
        XOR :xor,
        AND :and.

    JOIN (ck,reset,xor,t)->dlat,
        (dlat,tog) ->and,
        (tog,dlat) ->xor.

    OUTPUT (dlat,and)

END.

#.....#
# The n-bit macro counter generator, en is the enable, the outputs #
#are msb(bit 1)....lsb,carry. This is the same order as ELLA strings are stored#
#.....#

MAC COUNT_SYNC(INT n) = (bool:ck,t_reset: reset,bool:en )

```

```

-> ((n)bool,bool):
(LET out = BASIC_COUNT(ck,reset,en) .

    OUTPUT IF n=1
    THEN ((1)out[1],out[2])
    ELSE (LET outn = COUNT_SYNC(n-1)(ck,reset,out[2]) .
        OUTPUT (outn[1] CONC out[1],outn[2])
        )
    FI
).

#a mod 2^xsize counter#
MAC MOD2_COUNTER_COL = (bool:ck,t_reset:reset)
->

BEGIN
    MAC S_TO_C = (STRING(xsize)bit:n)
    (t_col):

    MAKE COUNT_SYNC(xsize):count,
    BOOL_STRING(xsize):b_s.
    (flag,t_col):BIOP_TRANSFORM_US.
->

JOIN (ck,reset,t) ->count, #count always enabled#
count[1]->b_s.
OUTPUT (S_TO_C b_s)[2]
END.

#a mod 2^ysize counter#
MAC MOD2_COUNTER_ROW = (bool:ck,t_reset:reset,bool:en)

```

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```

->
BEGIN
    MAC S_TO_R = (STRING[ysize]bit:in)
    (l_row):

    MAKE COUNT_SYNC[ysize]:count,
    BOOL_STRING[ysize] b_s.
    (flag,l_row):BIOP TRANSFORM_US.

    JOIN (ck,reset,en) ->count,
    count[1] ->b_s.
    OUTPUT (S_TO_R b_s)[2]
    END.

#the basic mod col_length counter, to be synthesised#
MAC BASE_COUNTER_COL = (bool:ck,l_reset:reset,STRING[xsize]bit:octave_cnt_length)
->
(l_col,l_count_control):

BEGIN
    MAC C_TO_S = (l_col: in)
    (flag,STRING[xsize]bit):BIOP TRANSFORM_US.

    MAC FINAL_COUNT = (l_col:in,STRING[xsize]bit:octave_cnt_length)
    (l_count_control):

    BEGIN
        LET in_us = (C_TO_S in)[2],
        lb= in_us[xsize].
        #OUTPUT CASE EQ_US(in_us[1..xsize-1],octave_cnt_length[1..xsize-1]) the msb's are the same#
        #ACTEL#

```

```

OUTPUT CASE ICMP8(in_us[1..xsize-1],octave_cnt_length[1..xsize-1]) #the msb's are the same#
OF I: CASE lsb
    #so check the lsb#
    OF b'1:count_carry, #count odd, so must be length#
        b'0:count_lm1 #count is even so must be length-1#
    ESAC
    ELSE count_rst
    ESAC
END.

MAKE MOD2_COUNTER_COL:mod2_count,
FINAL_COUNT:final_count.

JOIN (mod2_count,octave_cnt_length) -->final_count.
(ck,CASE reset #system reset or delayed carryout reset#
    OF rst: rst
    ELSECASE DFF_NO_LOAD(l_count_control)(ck,reset,final_count,count_0) #latch to avoid glitches#
        OF count_carry:rst
        ELSE no_rst
        ESAC
    ESAC)
-->mod2_count.

OUTPUT (mod2_count,final_count)
END.

FN COL_COUNT_ST = (bool:ck,1,reset:reset,STRING(xsize):octave_cnt_length)
-->
(l_count_control):
#count value , and flag for count=0,1,2,col_length-1,col_length#

BEGIN
    MAKE BASE_COUNTER_COL:base_col.
    LET count_control = CASE reset

```



```

OF rst:count_0
  ELSE CASE base_col[1]
    OF
      col/0:count_0,
      col/1:count_1,
      col/2:count_2,
      col/3:count_3
    ELSE base_col[2]
      ESAC
    ESAC.
  JOIN (ck, reset,octave_cnt_length) ->base_col.
  OUTPUT (base_col[1],count_control)
END.

#the basic mod row_length counter, to be synthesised#
MAC BASE_COUNTER_ROW = (bool:ck,1,reset:reset,bool:en,STRING[ysize]bit:octave_cnt_length,l_count_control:col_carry)
->
(l_row,l_count_control):

BEGIN

MAC R_TO_S = (l_row:ln)
->
(flag,STRING[ysize]bit): BIOP TRANSFORM_US.
MAC FINAL_COUNT = (l_row:ln,STRING[ysize]bit:octave_cnt_length)
->
l_count_control:

BEGIN
LET ln_us = (R_TO_S ln)[2].
lsb=ln_us[ysize].
#OUTPUT CASE EQ_US(ln_us[1..ysize-1],octave_cnt_length[1..ysize-1]) the mab's are the same#

```

```

#ACTEL#
OUTPUT CASE ICMP8(in_us[1..ysize-1],octave_cnt_length[1..ysize-1]) #the msb's are the same#
OF I: CASE lab
    OF b'1:count_carry. #count odd, so must be length#
        b'0:count_fm1 #count is even so must be length-1#
            ESAC
        ELSE count_rst
            ESAC
    END.
MAKE MOD2_COUNTER_ROW:mod2_count,
FINAL_COUNT:final_count.

#need to delay the reset at end of count signal till end of final row#
#WAS DFF WITH reset#
LET count_reset = DF1(I_rst){(ck,CASE(final_count,col_carry) #last row/last col#
    OF (count_carry,count_carry):rst #latch to avoid glitches#
    ELSE no_rst
        ESAC).

JOIN (mod2_count,octave_cnt_length) -> final_count,
(ck,CASE reset
    OF rst: rst
        ELSE count_reset
            ESAC,en) -> mod2_count.
OUTPUT (mod2_count,final_count)
END.

FN ROW_COUNT_CARRY_ST = (bool:ck,rst_reset:reset,STRING[ysize]bit:octave_cnt_length,i_count_control:col_carry)
->
(I_row,i_count_control):

```

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```

BEGIN
    MAKE BASE_COUNTER_ROW_base_row.
    LET count_control = CASE reset
        OF rst:count_0
            ELSE CASE base_row[1]
                OF row/0:count_0,
                    row/1:count_1,
                    row/2:count_2,
                    row/3:count_3
                    ELSE base_row[2]
                ESAC
            ESAC.
        END.

    JOIN (ck,reset,CASE col_carry
        OF count_carry:1
            ELSE 1
            ESAC,octave_cnt_length,col_carry) ->base_row.

    OUTPUT (base_row[1],count_control)
    END.

#the discrete wavelet transform chip/ multi-octave/2d transform with edge compensation#
#when ext & csl are both low latch the setup params from the nubus(active low), as follows#
bad[1..4] select function#
# 0000 load max_octaves, luminance/colour, forward/inversebar#
# 0001 load yimage#
# 0010 load ximage#
#jump table values#
# 0011 load ximage+1#
# 0100 load 3ximage+3#
# 0101 load 7ximage+7#

```

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```

# 0110 load base u addr#
# 0111 load base v addr#

#ad[21..22] max_oclaves#
#ad[23]luminance/crominancebar active low, 1 is luminance, 0 is colour#
#ad[24]forward/inversebar active low, 1 is forward, 0 is inverse#

#ad[5..24] data (bit 24 lsb)#

FN ST_OCT = (STRING[2]bit:st)
->
    (flag, l_octave): BIOP TRANSFORM_US.

FN OCT_ST = (l_octave:st)
->
    (flag, STRING[2]bit):BIOP TRANSFORM_US.

FN DWT = (bool:ck_in, l_reset:reset_in, l_input:in_in, bcol:extwrite_l_in col_in, STRING[24]bit:adi,
    l_input:sparc_mem_in, [4]l_scratch:pdcl_in)

->
    (l_input#out IDWT data#[3]l_load#valid out IDWT data,y,u,v#,
    [3]l_load#valid in DWT data y,u,v#,
    l_sparcport#sparc_data_addr, etc#,
    l_memport#pdcl_data_out#):

BEGIN
MAKE CONV_2D:conv_2d.
ADDR_GEN_NOSCRATCH:addr_gen.
#active low clock & enable latch#

```

```

[2]DLE1D:max_oclave_sl,
DLE1D:channel_factor_sl,
DLE1D:dir,
[9]DLE1D:col_length_s,
[9]DLE1D:row_length_s,
[9]DLE1D:x_p_1,
[11]DLE1D:x3_p_1,
[12]DLE1D:x7_p_1,
[19]DLE1D:base_u,
[19]DLE1D:base_v,
#active low 3X8 decoder#
DEC3X8A                                :decodel,
#the oclave control#
DFF_INIT[!_oclave]:oclave,
DFF_INIT[!_channel]:channel,
JKFF:row_carry_ff,
#pads#
INBUF[STRING[24]dt]zdt_out,
CLKBUF:ck,
INBUF[bool]:extwritel_csl,
INBUF[!_reset]:reset,
INBUF[!_input]:in_sparc_mem,
INBUF[[4]!_scratch]:pdel,
OBHS[!_input]:out1,
OBHS[[3]!_load]:out2 out3,
OBHS[!_sparcport]:out4,
OBHS[!_memport]:out5,
#must delay the write control to match the data output of conv_2d, ie by conv2d_latency#
LET
#set up the control params#

```

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```

max_oct = (ST_OCT_BOOL_STRING(2)max_octave_sl)[2],
channel_factor= CAST(l_channel_factor)channel_factor_sl,
col_length = BOOL_STRING(9) col_length_sl,
row_length = BOOL_STRING(9) row_length_sl,

direction =CASE dir
OF f:forward,
   i:inverse
   ESAC,

#set up the octave params#
convcol_row= conv_2d[3],
convcol_col=conv_2d[4],
convrow_col=conv_2d[5],
#signals that conv_col, for forward, or conv_row, for inverse, has finished that octave#
#and selects the next octave value and the sub-image sizes#

octave_finished =CASE direction
OF forward:CASE (row_carry_sl,convcol_row,convcol_col)
OF (l_count_2,count_2).write #row then col, gives write latency#
ELSE read
   ESAC,
   inverse:CASE (row_carry_sl,convcol_row,convrow_col)
OF (l_count_2,count_3).write #extra row as col then row#
ELSE read
   ESAC
   ESAC,
#max octaves for u/v#

```

```

max_oct_1 = CASE max_oct
OF oct/1:oct/0,
   oct/2:oct/1,
   oct/3:oct/2
ESAC,

y_done = CASE (channel,(OCT_ST octave)[2] EQ_US CASE direction
OF forward:CAST(STRING (2)pt)max_octave_sl,
   inverse:b"00"
ESAC)
OF (y,i):1
ELSE 1
ESAC,

uv_done = CASE (channel,(OCT_ST octave)[2] EQ_US CASE direction
OF forward:(OCT_ST max_oct_1)[2],
   inverse:b"00"
ESAC)
OF (u/v,i):1
ELSE 1
ESAC,

next= (SEQ VAR new_oct:=octave,
           new_channel:=channel;
           CASE direction
OF forward:(CASE octave
OF oct/0:new_oct:=oct/1,
   oct/1:new_oct:=oct/2,
   oct/2:new_oct:=oct/3

```

```

ESAC;

CASE (y_done,uv_done)
OF (t,bool)((bool,t).new_oct:=oct/0
ELSE
ESAC
),

inverse:(CASE octave
OF oct/3:new_oct:=oct/2,
oct/2:new_oct:=oct/1,
oct/1:new_oct:=oct/0
ESAC;
CASE channel
OF y:CASE octave
OF oct/0:CASE channel_factor #watch for colour#
OF luminance:new_oct:=max_oct
ELSE new_oct:=max_oct_1
ESAC

ELSE
ESAC,
u:CASE octave
OF oct/0:new_oct:=max_oct_1
ELSE
ESAC,
v:CASE octave
OF oct/0:new_oct:=max_oct #move to y#
ELSE
ESAC
ESAC)

```



```

ESAC;
CASE channel_factor
OF luminance:new_channel:=y,
   color:(CASE (channel,y_done)
OF (y,i):new_channel:=u
ELSE
ESAC;
CASE (channel,uv_done)
OF (u,i):new_channel:=v,
   (v,i):new_channel:=y
ELSE
ESAC)
ELSE
ESAC;
OUTPUT (new_oct,new_channel)
),

octave_sel = CASE (octave,channel) #the block size divides by 2 every octave#
OF (oct/0,y):uno, #the uv image starts 1/4 else#
   (oct/1,y):(oct/0,u|v):dos,
   (oct/2,y):(oct/1,u|v):tres,
   (oct/3,y):(oct/2,u|v):quatro
ESAC,
octave_row_length = MUX_4[STRING [ysize|bit]](row_length,b'0' CONC row_length[1..ysize-1],
   b'00' CONC row_length[1..ysize-2],
   b'000' CONC row_length[1..ysize-3],octave_sel),
octave_col_length = MUX_4[STRING [xsize|bit]](col_length,b'0' CONC col_length[1..xsize-1],
   b'00' CONC col_length[1..xsize-2],
   b'000' CONC col_length[1..xsize-3],octave_sel),

```

```

#bad next octave, either on system reset, or write finished#
load_octave= CASE reset
               OF rst:write
               ELSE octave_finished
               ESAC,

#reset the convolvers at the end of an octave, ready for the next octave#
#latch pulse to clean it, note 2 reset pulses at frame start#
#cant glitch as reset&octave_finished dont change at similar times#
conv_reset = CASE reset
               OF rst:rst
               ELSE CASE DFF_NO_LOAD(!_bad)(ck,reset, octave_finished,read)
               OF write:rst
               ELSE no_rst
               ESAC
               ESAC.

#latch control data off nbus, latch control is active low#
gl = CASE (extwritel,cal)
     OF (!,!).f
     ELSE 1
     ESAC,

sparc_w=addr_gen[1][2][1]. #write addresses#

input_mux=addr_gen[1][1]. #input_mux#

sparc_r=addr_gen[1][2][2]. #read addresses#

sparc_rw = addr_gen[1][2][3].

```

```

inverse_out = CASE (direction,octave)
  OF
    (inverse,oct/0):CASE (channel,addr_gen[2])
      OF
        (y,write):(write,read,read),
        (u,write):(read,write,read),
        (v,write):(read,read,write)
      ELSE (read,read,read)
    ESAC,
    (forward,oct/0):(read,read,read)
  ELSE (read,read,read)
ESAC,
forward_in = CASE direction
  OF
    forward:CASE (channel,octave,addr_gen[3])
      OF
        (y,oct/0,read):(read,write,write),
        (u,oct/0,read):(write,read,write),
        (v,oct/0,read):(write,write,read)
      ELSE (write,write,write)
    ESAC,
    inverse:(write,write,write)
  ESAC.

```

```

JOIN
#in pads#
  ck_in      ->ck,
  reset_in->reset,
  extwritel_in ->extwritel,
  cal_in      ->cal,
  adl        ->adl_out,
  in_in      ->in,
  spare_mem_in ->spare_mem,
  pdel_in    ->pdcl,
#out pads#

```

```

conv_2d[1]    ->out1,
inverse_out   ->out2,
forward_in    ->out3,
addr_gen[1][2] ->out4,
conv_2d[2] ->out5,

```

```

#the control section#

```

```

(CAST[bool]ad[4],CAST[bool]ad[3],CAST[bool]ad[2]) ->decode1, #active low out5#

```

```

(g1,decode[1],BIT_BOOLadl_out[21]) ->max_octave_sl[1],
(g1,decode[1],BIT_BOOLadl_out[22]) ->max_octave_sl[2],

```

```

(g1,decode[4],BIT_BOOLadl_out[23]) ->channel_factor_sl,
(g1,decode[1],BIT_BOOLadl_out[24]) ->dir.

```

```

FOR INT j=1..9 JOIN

```

```

(g1,decode[2],BIT_BOOLadl_out[15+j]) ->col_length_sl[j],
(g1,decode[3],BIT_BOOLadl_out[15+j]) ->row_length_sl[j],
(g1,decode[4],BIT_BOOLadl_out[15+j]) ->x_p_1[j].

```

```

FOR INT j=1..11 JOIN

```

```

(g1,decode[5],BIT_BOOLadl_out[13+j]) ->x3_p_1[j].

```

```

FOR INT j=1..12 JOIN

```

```

(g1,decode[6],BIT_BOOLadl_out[12+j]) ->x7_p_1[j].

```

```

FOR INT j=1..19 JOIN

```

```

(g1,decode[7],BIT_BOOLadl_out[5+j]) ->base_u[j],
(g1,decode[8],BIT_BOOLadl_out[5+j]) ->base_v[j].

```

```

#sets a flag when row counter moves onto next frame#

```

```

JOIN

```

```

(ck,conv_reset,CASE convcol_row

```

```

OF count_carryt

```

```

ELSE 1

```

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```

ESAC,i)                                ->row_carry_fl,

#load the new octave,after the current octave has finished writing#
# on initial reset must load with starting octave value which depends on direction and channel#
(ck,no_rst,load_octave,CASE reset
  OF no_rst,next[1]
  ELSE CASE (direction,channel) #initial octave#
    OF (forward,t_channel):oct0,
      (inverse,y):max_oct,
      (inverse,uv):max_oct_1
    ESAC
    ESAC,oct0)                          ->octave, #next octave#
(ck,no_rst,load_octave,CASE reset
  OF no_rst,next[2]
  ELSE y
  ESAC,y)                              ->channel, #next channel#

(ck,reset,MUX_2[!_input])(m,spare_mem,CASE input_mux #input_mux#
  OF dwt_in:left,
    spare_in:right
  ESAC)
,direction,pdel,conv_reset,addr_gen[4],addr_gen[5]) ->conv_2d,

(ck,reset,direction,channel,BOOL_STRING[9]x_p_1,BOOL_STRING[11]x3_p_1,BOOL_STRING[12]x7_p_1,octave_row_length,
octave_col_length,conv_reset,octave_y_done,uv_done,octave_finished,BOOL_STRING[19]base_u,BOOL_STRING[19]base_v) ->addr_gen.

OUTPUT      (out1,out2,out3,out4,out5)
END.
FN DWT_TEST = (bool:ck_in,!_reset:reset_in,!_input:in_in,bool:extwritel_in cal_in,!_spare_addr:reg_sel value)

```

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```

->
        (t_input[3]t_load[3]t_load):
BEGIN
    FN SPARC_MEM = (t_input.in,t_sparc_addr.wr_addr,t_sparc_addr.rd_addr,t_load.rw_sparc#.t_cs.cs#)
->
        t_input:
        RAM(input/0).

    MAKE DWT:dwt,
        SPARC_MEM:sparc_mem,
        LINE_DELAY(t_scratch):line_delay.

    LET  data_out=dwt[1],
        sparc_port=dwt[4],
        line_delay_port = dwt[5].

    JOIN
        (ck_in,reset_in,in_in,extwritel_in,cal_in,(SPA_S reg_sel)[2][16..19]CONC b"1" CONC(NOT_B (SPA_S value)[2]),sparc_mem,line_delay)
        ->dwt,
        (data_out,sparc_port[1],sparc_port[2],sparc_port[3]#sparc_port[4]#) ->sparc_mem,
        (line_delay_port[1],line_delay_port[2],line_delay_port[3],write) ->line_delay.

    OUTPUT  dwt[1..3]
    END.

    # some basic macros for the convolver, assume these will#
    #be synthesised into leaf cells#
    #the actel MX4 mux cell#
    FN NOT = (bool:in)
->
    bool:CASE in OF 1:1,1:1 ESAC.

```

MAC MX\_4[TYPE ty]=(ty.in1 in2 in3 in4, [2]bool:sel)

->

ty:

CASE sel  
OF (1,0).in1,  
(1,1).in2,  
(1,2).in3,  
(1,3).in4

ESAC.

#the actel GMX4 mux cell#

MAC GMX4[TYPE ty]=(ty.in1 in2 in3 in4, [2]bool:sel)

->

ty:

CASE sel  
OF (1,0).in1,  
(1,1).in2,  
(1,2).in3,  
(1,3).in4

ESAC.

MAC MXT[TYPE ty]=(ty.a b c d, bool:soa sob s1)

->

ty:

CASE s1  
OF 1: CASE soa  
OF 1b  
ELSE a  
ESAC,  
1: CASE sob

```

OF l:d
ELSE c
ESAC
ESAC.
MAC ENCODE4_2 = (l_mux4.in)
->
[2]bool:
CASE in
OF uno:(l,f),
dos:(l,l),
tres:(l,f),
quatro:(l,l)
ESAC.

MAC ENCODE3_2 = (l_mux3.in)
->
[2]bool:
CASE in
OF l:(l,f),
c:(l,l),
r:(l,f)
ESAC.

FN DEC3X8A = (bool:a b c)
->
[8]bool:
CASE (a,b,c)
OF ((l,f):(l,l,l,l,l,l,l,l)),
((l,f):(l,l,l,l,l,l,l,l)),
((l,f):(l,l,l,l,l,l,l,l)),
((l,f):(l,l,l,l,l,l,l,l)),

```



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```

((1,0):(0,1,1,1,1,1,0),
(1,0):(0,1,1,1,1,1,0),
(1,0):(0,1,1,1,1,1,0),
(1,1):(0,1,1,1,1,1,0)
ESAC.

```

```

MAC_MUX_2(TYPE 1)=(in1 in2, l_muxsel)
->

```

```

t:
CASE sel
OF left:in1,
   right:in2
ESAC.

```

```

MAC_MUX_3(TYPE 1)=(in1 in2 in3, l_mux3sel)
->

```

```

t:
MX_4(i)(in1,in2,in3,in1,ENCODE3_2 sel).

```

```

COM

```

```

MAC_MUX_4(TYPE 1)=(in1 in2 in3 in4, l_mux4sel)
->

```

```

t:
CASE sel
OF uno:in1,
   dos:in2,
   tres:in3,
   quatre:in4
ESAC.
MOC

```

```

MAC_MUX_4(TYPE t)=(t:in1 in2 in3 in4, t_mux4:sel)
->
t:
MX_4(t)(in1,in2,in3,in4,ENCODE4_2_sel).

FN AND2 = (bool:a b)
->
bool:BIOP AND.

MAC GNAND2 = (bool:a b)
->
bool:NOT AND2(a,b).

MAC AND_2 = (t_scratch:in, t_and:sel)
->
t_scratch:
BEGIN
LET in_s = (t TO S{scratch_exp}in)[2],
sel_s = CAST{bool}sel.
OUTPUT (S_TO_I{scratch_exp}BOOL_STRING{scratch_exp} ((INT)-1..scratch_exp)AND2(BIT_BOOL in_sel_sel_s)))[2]
END.

FN XOR = (bool: a b)
->
bool:
CASE (a,b)
OF (t,t):(t,t):1
ELSE 1
ESAC.

```

MAC XOR\_B(INT n) = (STRING[n]bit:a b)

->

STRING[n]bit:BIOP XOR.

MAC NOT\_B = (STRING[INT n]bit:a)

->

STRING[n]bit:BIOP NOT.

MAC XNOR\_B = (STRING[INT n]bit:a b)

->

STRING[n]bit:

NOT\_B XOR\_B(n)(a,b).

FN AND = (bool: a b)

->

bool:

CASE (a,b)

OF (1,1):1

ELSE 1

ESAC.

MAC DEL(TYPE i) = (i)

->

i:DELAY(1,1).

#a general dff same as DFF\_NO\_LOAD#

MAC DFF (TYPE i)=(bool:ck,1\_reset,reset,1\_in init\_value)

->

i:

BEGIN

```
MAKE DEL(i):del.  
JOIN in->del.  
OUTPUT CASE reset  
  OF rat:init_value  
    ELSE del  
      ESAC  
END.
```

```
#a general dfi#  
MAC DF1 (TYPE t)=(bod:ck,t:in)  
->  
t:  
BEGIN  
MAKE DEL(i):del.  
JOIN in->del.  
OUTPUT del  
END.
```

```
#a general latch#  
MAC DL1 (TYPE ty)=(bod:ck,ty:in)  
->  
ty:  
BEGIN  
MAKE DEL(iy):del.  
JOIN CASE ck  
  OF t:in  
    ELSE del  
      ESAC ->del.  
OUTPUT CASE ck  
  OF t:in
```

```

ELSE del
ESAC

END.

#a general d latch#
MAC LATCH (TYPE i)=(bool:ck,l_load:load,t:tn)
->
i:
BEGIN
MAKE DEL(i):del.
LET out=CASE load
OF write:tn
ELSE del
ESAC.
JOIN out->del.
OUTPUT out
END.

#an ACTEL D LATCH#
MAC DLE1D = (bool:ckl loadl,bool:tn)
->
bool:#qn#
NOT LATCH(bool)(NOT ckl CASE loadl
OF f:write
ELSE read
ESAC, tn).

MAC PDF1(TYPE i,INT n) = (bool:ck,l_resel:resel,t:tn initial_value)
->
i:
IF n=0 THEN DFF(i)(ck,resel,tn,initial_value)

```

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```

ELSE PDF1(l,n-1)(ck,reset,DFF1)(ck,reset,in,initial_value),initial_value)
FI.

```

```

#a muxed input dff#
MAC DFM (TYPE ty)=(bool:ck,ty:a b,bool:x)
->
ty:
BEGIN
MAKE DEL(ty):del.
JOIN CASE s
  OF t:a,
     t:b
  ESAC ->del.
OUTPUT del
END.
#a resetable DFF, init value is input parameter#
MAC DFF_INIT(TYPE t)=(bool:ck,t_reset:reset,t_load:load,t_in init_value)
->
t:
BEGIN
MAKE DEL(t):del.
LET out=CASE (load,reset)
  OF (write,t_reset):in,
     (read,rs1)init_value
  ELSE del
  ESAC.
JOIN out->del.
OUTPUT CASE reset
  OF rst:init_value
  ELSE del

```

```

ESAC
END.

```

```

#a resetable JKFF, k Input is active low#
FN JKFF=(bool:ck,t_reset:reset,bool:j k)
->

```

```

bool:
BEGIN
MAKE DEL(bool):del.
LET out=CASE (j,k,reset)
  CF (t,t,no_reset):t,
    (t,t,reset):f,
    (t,f,reset):t,
    ((t,t,no_reset):f,
    ((t,t,no_reset):del,
    ((t,f,no_reset):NOT del

```

```

ESAC.

```

```

JOIN out->del.

```

```

OUTPUT CASE reset

```

```

OF rst:f

```

```

ELSE del

```

```

ESAC

```

```

END.

```

```

#a diff resetable non-loadable diff#

```

```

MAC DFF_NO_LOAD(TYPE t)=(bool:ck,t_reset:reset,t in init_value)
->

```

```

t:

```

```

BEGIN

```

```

MAKE DEL(t):del.

```

```

JOIN in->del.

```

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```

OUTPUT CASE reset
  OF rst_init_value
  ELSE del
  ESAC
END.

MAC PDEL(TYPE t,INT n) = (t:n)
->
t:
  IF n=0 THEN DEL(t)in
  ELSE PDEL(t,n-1) DEL(t) in
  FI.

#the mem control unit for the DWT chip, outputs the memport values for the sparc, and dwt#
#inputs datain from these 2 ports and mux's it to the 2d convolver.#

MAC MEM_CONTROL_NOSCRATCH = (bool:ck,t_reset:reset,t_direction:direction,t_channel:channel,t_octave:octave,
                             t_sparc_addr:sparc_addr,w_sparc_addr_r,t_load:zero_hh)

->
  ((t_input_mux,t_sparcport,t_dwtport#dwt#):

BEGIN
#the comb. logic for the control of the i/o ports of the chip#
LET ports = (SEQ

  VAR #defaults, so ? doesn't kill previous mem value#
  rw_sparc:=read,
  rw_dwt:=read,
  cs_dwt:=no_select,
  input_mux:=sparc_in;

```



```

CASE (direction,octave)
  OF
    (forward,oct0): ( cs_dwt:=select;
                      input_mux:=dwt_in),
    (inverse,oct0): ( CASE zero_hh
                      OF  write:(rw_dwt:=write;
                                cs_dwt:=select)
                      ELSE
                        ESAC)

    ESAC;

#rw_sparc=write when ck=1 and zero_hh=write, otherwise = read#
rw_sparc:= CAST(1_load)GNAND2(NOT CAST(bool)zero_hh,ck);

#mux the sparc addr on clock#
#   sparc_addr = GMX4(1_sparc_addr){sparc_r,sparc_w,sparc_w,ck,0};#

OUTPUT (input_mux, (sparc_addr_w,sparc_addr_r,rw_sparc),  #sparc port#
        (rw_dwt,cs_dwt)
        )

).
OUTPUT ports
END.

# the basic 1d convolver without the control unit#

MAC MULT_ADD = (bool:ck,1_reset:reset,1_input_in,[3]t_and:andsel,[2]t_mux:centermuxsel,[3]t_mux4:muxsel,
                 [3]t_and:muxandsel,[4]t_add:adddel,1_direction:direction,[4]t_scratch:pdcl)
->
    [4]t_scratch: #pdcl are the outputs from the line delays#

```

```

BEGIN
    MAKE MULTIPLIER:mult,
    [4]ADD_SUB: add.
    #the multiplier outputs#
    LET x3=mult[1],
    x5=mult[2],
    x11=mult[3],
    x19=mult[4],
    x2=mult[5],
    x8=mult[6],
    x30=mult[7],

    #the mux outputs#
    mux1=MUX_4(l_scratch)(x11,x5,x8,x2,muxse[1]),
    mux2=MUX_4(l_scratch)(x19,x30,x8,scratch0,muxse[2]),
    mux3=MUX_4(l_scratch)(x11,x5,x8,x2,muxse[3]),
    centermux=(MUX_2(l_scratch)(pde[1],pde[3],centermuxse[1]),
    MUX_2(l_scratch)(pde[2],pde[4],centermuxse[2]) ),

    # the AND gates zero the adder inputs every 2nd row#
    #the and gate outputs#
    and1=AND_2(pde[2],andse[1]),
    and2=AND_2(pde[3],andse[1]),
    and3=AND_2(centermux[1],andse[2]),
    and4=AND_2(centermux[2],andse[3]),
    add1in=AND_2(mux1,muxandse[1]),

```

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```

add3in=AND_2(mux3,muxandse[2]),
add4in=AND_2(x3,muxandse[3]).

```

```

JOIN in ->mult,
      (and1,add1in,addse[1]) ->add[1],
      (and3,mux2,addse[2]) ->add[2],
      (and4,add3in,addse[3]) ->add[3],
      (and2,add4in,addse[4]) ->add[4].

```

OUTPUT add

END.

# the basic multiplier unit of the convolver #

```

MAC MULTIPLIER_ST = (t_input:in)

```

->

```

      [7]_scratch:
      #x3,x5,x11,x19,x2,x8,x30#

```

BEGIN

```

MAC INPUT_TO_S(INT n) = (t_input: in)

```

->

```

      (flag,STRING(nbit)): BIOP TRANSFORM_S.

```

#the multiplier outputs, fast adder code commented out#

```

LET in_s = (INPUT_TO_S(input_exp[1n][2],
      x2=in_s CONC b'0',
      x8=in_s CONC b'000',
      x3 = ADD_S_ACTEL(in_s, x2,b'1),
      x5 = ADD_S_ACTEL(in_s,in_s CONC b'00',b'1),
      x11 = ADD_S_ACTEL(x3,x8,b'1),
      x19 = ADD_S_ACTEL(x3,in_s CONC b'0000',b'1),

```

```

x30=ADD_S_ACTEL(x11,x19,b'1).

LET subsignal = (x2,x8, x3,x5, x11,x19,x30).
OUTPUT ((S_TO_[input_exp+2] x3)[2],(S_TO_[input_exp+3] x5)[2],(S_TO_[input_exp+4] x11)[2],
        (S_TO_[input_exp+5] x19)[2],(S_TO_[input_exp+1] x2)[2],(S_TO_[input_exp+3] x8)[2],
        (S_TO_[input_exp+6] x30)[2])
END.
MAC INBUF(TYPE l) = (l:pad)
->
l: #y #pad.

MAC OBHS(TYPE l) = (l:d)
->
l: #pad #d.

FN CLKBUF = (bool:pad)
->
bool:pad.
#MAC SHIFT(INT p) = (STRING[ecratch_exp]bit) -> STRING[ecratch_exp+p]bit:BIOP SR_S[p].#

MAC ADD_S = (STRING(INT m)bit,STRING(INT n)bit)
->
STRING(IF m>=n THEN m+1 ELSE n+1 F)bit:
BIOP PLUS_S.

MAC INV(INT m) = (STRING(m)bit:a)
->
STRING(m)bit:BIOP NOT.

MAC NEG_S = (STRING(INT n)bit)
->

```

```
STRING[n+1]bit:
BIOP NEGATE_S.
```

```
MAC ADD_US = (STRING[INT m]bit, STRING[INT n]bit)
```

```
->
```

```
STRING[IF m>n THEN m+1 ELSE n+1 F]bit:
BIOP PLUS_US.
```

```
MAC CARRY = (l_add:in)
```

```
->
```

```
STRING[1]bit: CASE in
```

```
OF add:b'0',
   sub:b'1'
```

```
ESAC.
```

```
#actel adder macros#
```

```
#an emulation of a fast ACTEL 16 bit adder with active low carries#
FN FADD16 = (STRING[scratch_exp]bit: a b, STRING[1]bit: cinb)
```

```
->
```

```
(STRING[scratch_exp]bit, STRING[1]bit):
```

```
BEGIN
```

```
LET a_c = a CONC INV[1]cinb.
```

```
b_c = b CONC INV[1]cinb.
```

```
out = ADD_S(a_c, b_c).
```

```
OUTPUT(out[2..scratch_exp+1], INV[1] B_TO_S out[1])
END.
```

```
#actel 1 bit full adder with active low cin and cout#
```

```
MAC FA1B = (bit: ain bin cinb)
```

```
->
```

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```

(bit,bit);#cob,s#
BEGIN
  LET  a_c=B_TO_S_ain CONC INV(1)B_TO_S_cinb,
        b_c=B_TO_S_bin CONC INV(1)B_TO_S_cinb,
        out=ADD_US(a_c,b_c).
  OUTPUT(CAST(bit) INV(1) B_TO_S_out(1),out(2))
END.

#the actel version of the ADD BIOP's#

MAC ADD_US_ACTEL = (STRING(INT m):ain,STRING(INT n):bin,bit:cinb)
->
  STRING(IF m>=n THEN m+1 ELSE n+1 F)bit:
BEGIN
  MAKE (IF m>=n THEN m ELSE n F)FA1B:sum.

#unsigned nos so extend by 0#
  LET a_c = IF m>=n THEN ain ELSE ZERO(n-m)b'0' CONC ain F1,
        b_c = IF n>=m THEN bin ELSE ZERO(m-n)b'0' CONC bin F1.
  LET subsignal = sum.

#lsb#
  JOIN  (a_c IF m>=n THEN m ELSE n F)b_c IF m>=n THEN m ELSE n F),cinb) ->sum(IF m>=n THEN m ELSE n F).

FOR INT j=1..(IF m>=n THEN m ELSE n F) -1
JOIN (a_c IF m>=n THEN m ELSE n F) -j,b_c IF m>=n THEN m ELSE n F) -j, sum((IF m>=n THEN m ELSE n F) -j+1 F(1))
->sum((IF m>=n THEN m ELSE n F) -j).

OUTPUT  CAST(STRING(IF m>=n THEN m+1 ELSE n+1 F)bit)
(INV(1) B_TO_S_sum(1)) CONC

```

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```

END.

CAST{STRING(IF m>=n THEN m ELSE n F1)bit} [INT j=1..IF m>=n THEN m ELSE n F1] sum[j][2]}

MAC ADD_S_ACTEL = (STRING(INT m)bit:ain, STRING(INT n)bit:bin, bit:cnb)
->
    STRING(IF m>=n THEN m+1 ELSE n+1 F1)bit:
BEGIN
    MAKE [IF m>=n THEN m ELSE n F1]FA1B:sum.

#signed nos 80 sign extend #
LET a_c = IF m>=n THEN ain ELSE ALL_SAME(n-m)B_TO_S ain[1] CONC ain F1,
    b_c = IF n>=m THEN bin ELSE ALL_SAME(m-n)B_TO_S bin[1] CONC bin F1.
    LET subequal = sum.

#lsb#
JOIN (a_c IF m>=n THEN m ELSE n F1), b_c IF m>=n THEN m ELSE n F1, cnb) ->sum[IF m>=n THEN m ELSE n F1].

FOR INT j=1..(IF m>=n THEN m ELSE n F1) -1
JOIN (a_c IF m>=n THEN m ELSE n F1) -j, b_c IF m>=n THEN m ELSE n F1 -j, sum[IF m>=n THEN m ELSE n F1] -j+1[1])
m>=n THEN m ELSE n F1) -j]. ->sum[IF

OUTPUT CAST{STRING(IF m>=n THEN m+1 ELSE n+1 F1)bit}
(INV(1) B_TO_S sum[1][1]) CONC
    CAST{STRING(IF m>=n THEN m ELSE n F1)bit} [INT j=1..IF m>=n THEN m ELSE n F1] sum[j][2]}
END.

FN ROUND_BITS = (L_scratch.in, L_round: select)
->
    L_input:
BEGIN

```

#THIS ASSUMES THAT THE INPUT\_EXP=101111#

#select chooses a round factor of 3, 4, 5#

#the lsb is the right hand of the string.#

#the index 1 of the string is the left hand end, & is the msb#

#so on add ops bit 1 is the carryout#

LET s1= (L\_TO\_S[scratch\_exp]in)[2].

msb= B\_TO\_S s1[1].

selector = CASE select #case conversion for MUX\_3#

OF shift3:1,

shift4 x,

shift5:r

ESAC,

#needs to be a 16 bit output for the adder#

shift = MUX\_3[STRING[scratch\_exp]bit](

msb CONC msb CONC msb CONC s1[1..scratch\_exp-3].

msb CONC msb CONC msb CONC msb CONC s1[1..(scratch\_exp-4)].

msb CONC msb CONC msb CONC msb CONC msb CONC s1[1..scratch\_exp-5].

selector

).

#the carry to round, 1/2 value is rounded towards 0#

cs = CASE select

OF shift4: CASE msb

OF b\*1":s1[scratch\_exp-3], #neg no.#

b\*0": CASE s1[scratch\_exp-3..scratch\_exp]

OF b\*1000":b\*0 #round down on 1/2 value#

ELSE s1[scratch\_exp-3]

ESAC



```

      ESAC,
shift3: CASE msb
  OF b'1': s1[scratch_exp-2], #neg no.#
  b'0': CASE s1[scratch_exp-2..scratch_exp]
    OF b'100': b'0 #round down on 1/2 value#
    ELSE s1[scratch_exp-2]
    ESAC

```

```

      ESAC,

```

```

shift5: CASE msb
  OF b'1': s1[scratch_exp-4], #neg no.#
  b'0': CASE s1[scratch_exp-4..scratch_exp]
    OF b'10000': b'0 #round down on 1/2 value#
    ELSE s1[scratch_exp-4]
    ESAC
      ESAC

```

```

      ESAC,

```

```

sum17 = ADD_US_ACTEL(B_TO_S cs, shift, b'1),
sum = sum17[2..scratch_exp+1],

```

```

#bit 1 is carry out, gives 16 bit sum#

```

```

subsignal=(cs,sum),

```

```

#ACTEL HACK#

```

```

soa = CASE sum{1}
OF b'1:1, #satrate to -512#
  b'0:1 #satrate to 512#
  ESAC,

```

```

ss1 = CASE selector

```

```

  OF 1: CASE sum[4..7] #these are the 5 msb's form the 13 bit word#
    OF (b'1111' | b'0000'): #value in range#

```

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```

ELSE I
ESAC,

c: CASE sum[5..7]#these are the 3 msb's from the 12 bit word left after#
    # taking out the 4 sign extension bits#
    OF (b'111' | b'000'): 1 #value in range#
    ELSE I
    ESAC,

r: CASE sum[6..7]#these are the 2 msb's from the 11 bit word#
    OF (b'11' | b'00'): 1 #value in range#
    ELSE I
    ESAC

    ESAC,
    out= MXT(STRING[scratch_exp-6]b1)(b'0111111111'b'1000000000',sum[7..scratch_exp],sum[7..scratch_exp],eoa,t,ss1).
    OUTPUT (S_TO_Nout)[2]
END.

MAC LINE_DELAY_ST(TYPE I)=([4]:in,I_col:wr_address,I_col:rd_address,I_load:rw)
->
[4]t:
RAM([4]?I).

FN PR_ADDER_ST = (I_scratch#b)
->
I_scratch:
(S_TO_I[scratch_exp] ADD_S((I_TO_S[scratch_exp-1]a)[2],(I_TO_S[scratch_exp-1]b)(2))) [2].

FN ADD_SUB_ST = (I_scratch: a b, I_addr:sel)
->

```

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```
l_scratch:
BEGIN
```

```
    LET a_s=(l_TO_S[scratch_exp]a)[2],
        b_s=(l_TO_S[scratch_exp]b)[2],
        sel_bit = CAST(STRING(1)bit)sel,
#ACTEL#
    b_s_inv = XOR_B[scratch_exp](b_s, ALL_SAME[scratch_exp]sel_bit).
```

```
#c1nb is active low so cast sel(add->0,sub->1) & invert it#
```

```
    out= ADD_S_ACTEL(a_s,b_s_inv,CAST(bit)INV(1)sel_bit),
    binout= out[2..scratch_exp+1].
```

```
    OUTPUT (S_TO_[scratch_exp]binout)[2]
END.
```

```
MAC ALL_SAME(INT n) = (STRING(1)bit:dummy)
```

```
->
```

```
STRING(n)bit:
```

```
BEGIN
```

```
    FAULT IF n < 1 THEN 'N<1 in ALL_SAME' FI.
```

```
    OUTPUT IF n=1 THEN dummy
```

```
    ELSE dummy CONC ALL_SAME[n-1] dummy
```

```
FI
```

```
END.
```

```
MAC CAST (TYPE to) = (TYPE from:tn)
```

```
->
```

```
    to:ALIEN CAST.
```

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MAC ZERO[INT n] = (STRING[1]bit:dummy)

->

STRING[n]bit:

BEGIN

FAULT IF n < 1 THEN "N<1 In ZERO" FI.

OUTPUT IF n=1 THEN b'0"

ELSE b'0" CONC ZERO[n-1] b'0"

FI

END.

MAC B\_TO\_S = (bit:in)

->

STRING[1]bit: CASE In  
OF b'0:b'0",

b'1:b'1"

ESAC.

MAC I\_TO\_S[INT n] = (t\_scratch:in)

->

(flag,STRING[n]bit): BIOP TRANSFORM\_S.

MAC S\_TO\_I[INT n] = (STRING[n]bit:in)

->

(flag,t\_scratch): BIOP TRANSFORM\_S.

MAC S\_TO\_IN = (STRING[input\_exp]bit:in)

->

(flag,t\_input): BIOP TRANSFORM\_S.

MAC IN\_TO\_S[INT n] = (t\_input:in)

->

(flag,STRING[n]bit): BIOP TRANSFORM\_S.

MAC U\_TO\_I[INT n] = (STRING[n]bit:in)

->

```
(flag, l_scratch): BIOP TRANSFORM_U.
```

```
MAC B_TO_I = (bit.in)
```

```
->
```

```
l_scratch: CASE in
```

```
OF b'0: scratch/0,  
   b'1: scratch/1
```

```
ESAC.
```

```
MAC CARRY = (l_add.in)
```

```
->
```

```
STRING[1]bit: CASE in
```

```
OF add: b'0',  
   sub: b'1'
```

```
ESAC.
```

```
MAC BOOL_BIT = (bool.in)
```

```
->
```

```
STRING[1]bit:
```

```
CASE in
```

```
OF 1: b'1'
```

```
ELSE b'0'
```

```
ESAC.
```

```
MAC BIT_BOOL = (bit.in)
```

```
->
```

```
bool:
```

```
CASE in
```

```
OF b'1
```

```
ELSE 1
```

```
ESAC.
```

```

MAC BOOL_STRING[INT n] = ([n]bool.in)
->
STRING[n] bit:
(LET out = BOOL_BIT In[1].
OUTPUT IF n=1
THEN out
ELSE out[1] CONC BOOL_STRING[n-1])(in[2..n])
FI
).

#define a few useful gates #
FN NOT = (bool:in) -> bool:
CASE in
OF 1:1,
   1:1
ESAC.

FN MUX = (bool:sel in1 in2) -> bool:
# two input mux, select in1 if sel =1, otherwise in2 #
CASE sel
OF 1:in2,
   1:in1
ESAC.

FN XNOR=(bool:in1 in2)->bool:
CASE (in1,in2)
OF (1,1)1,
   (1,1)1,
   (1,1)1,
   (1,1)1
ESAC.

```

```

FN XOR=(bool:in1 in2) ->bool:
CASE (in1,in2)
OF (1,1):1,
   (1,0):1,
   (0,1):1,
   (0,0):1
ESAC.

FN OR = (bool:in1 in2) ->bool:
CASE (in1,in2)
OF (1,1):1,
   (1,0):1,
   (0,1):1,
   (0,0):1
ESAC.

#FN MYLATCH = (bool:in) ->bool:DELAY(1,1).#

FN MYLATCH = (t_reset:reset,bool:in) ->bool:
BEGIN
MAKE PDEL(bool,0):del.
LET out = CASE reset
OF rst:1
ELSE del
ESAC.
JOIN in->del.
OUTPUT out
END.

TYPE t_test = NEW(no)yes).
#.....#
#These functions change types from boolean to integer and vice-#
#versa. Supports 1 & 8 bit booleans. #
#.....#

```

```

FN INT_BOOL=(l_input:k)    ->bool:      # 1bit input to binary #
CASE k
OF
  input/0:1,
  input/1:1
ESAC.

```

```

FN BOOL_INT=(bool:b) ->l_input:      # 1 bit bool to input #
CASE b
OF
  input/0,
  input/1
ESAC.

```

```

FN * =(l_input:a b)    ->l_input: ARITH a*b.
FN % =(l_input:a b)    ->l_input: ARITH a%b.
FN - =(l_input:a b)    ->l_input: ARITH a-b.
FN + =(l_input:a b)    ->l_input: ARITH a+b.
FN = =(l_input:a b)    ->l_test: ARITH IF a=b THEN 2 ELSE 1 FI.

```

COM

```

FN CHANGE_SIGN = (l_input:i) ->l_input:      #changes sign for 8-bit 2's#
ARITH IF i<0 THEN 128+i    #complement no. #
ELSE i
FI.

```

```

FN SIGN = (l_input:i) ->bool:      #gets sign for 2's#
ARITH IF i<0 THEN 1      #complement nos #
ELSE 2
FI.

```

```

FN TEST_SIZE = (l_input:x) ->bool:

```



```

#tests to see if the input is bigger than an 8-bit integer#
  ARITH IF ( (x<=-128) AND (x>127)) THEN 1
        ELSE 2      FI.

```

```

FN INT8_BOOL=(i_input:orig) ->[8]bool:
BEGIN

```

```

  SEQ

```

```

    VAR i1:=input/0,      #input variables#
        i0:=CHANGE_SIGN(orig),
        b:=(1,1,1,1,1,SIGN(orig));

```

```

    [INT n=1..7] (
        i1:=i0%input/2;
        b[n]:=INT_BOOL(i0-input/2*i1);
        i0:=i1
    );

```

```

    OUTPUT CASE TEST_SIZE orig      #checks to see if orig will#
    OF      i:  [8]?bool,      #fit input to an 8_bit value#
            f:  b
    ESAC

```

```

END.

```

```

FN BOOL_INT8=([8]bool:b) ->_i_input:      #converts 8bit boolean to 2's#
BEGIN

```

```

  SEQ

```

```

    VAR sum:=input/-128 * BOOL_INT(b[8]),
        exp:=input/1;

```

```

    [INT k=1..7]
    (
        sum:=sum+exp*BOOL_INT(b[k]);
        exp:=input/2 * exp
    )

```

```

);
OUTPUT sum
END.

MOC
FN BOOL_INT10=(l10)bool:b) ->l_input: #converts 10bit boolean to 2's#
BEGIN
    SEQ
    VAR sum>input/-512*BOOL_INT(b10); #complement integer #
    exp:=input/1;
    [INT k=1..8]
    (
        sum>sum+exp*BOOL_INT(b[k]);
        exp:=input/2*exp
    );
    OUTPUT sum
END.
COM
FN BOOL_INT16 =(l16)bool:in1 in2) ->l_input:
# converts a 16-bit no. (l16a,m16a) input to integer form#
(BOOL_INT8(in1))+((input/256)*BOOL_INT8(in2))+((input/256)*BOOL_INT(in18)).
#hack because of sign extend#
#of l16 #

MOC
#compute the mean square difference between two arrays of integers#
FN MSE_COLOUR = (l_reset:reset,l_input:a b) ->[2]l_int32:
BEGIN
    FN SAVE_ERROR = (l_reset:reset,l_int32:diff32) ->l_int32:
    BEGIN
        MAKE PDEL(l_int32,0) del,

```

```

        PDEL(l_reset,0):edge.

LET  rising = CASE (reset,edge)
      OF  (no_reset,0):diff32,
          (no_reset,no_reset):del PL diff32
      ELSE del
      ESAC.

JOIN  rising ->del,
      reset ->edge.

OUTPUT  del
END.

MAKE  SAVE_ERROR:save_error.
LET  out = (SEQ
            STATE VAR true_count INIT int32/1;
            VAR diff:=int32/0;
            diff32:=int32/0,
            incr:=int32/0;

            diff:=CASE reset
                    OF reset:int32/0
                    ELSE l_32(a) MI l_32(b)
                    ESAC;
            incr:=CASE reset
                    OF reset:int32/0
                    ELSE int32/1
                    ESAC;
            true_count:= CASE reset
                    OF reset:int32/1
                    ELSE true_count PL incr
                    ESAC;

```

```

diff32:= (diff T1 diff);

OUTPUT (diff32,true_count) );

JOIN      (reset,out[1])      -->save_error.
OUTPUT    (save_error,save_error DV out[2])
END.

```

#compute the mean square difference between two arrays of integers#

```

TYPE l_int32 = NEW int32/(-2147483000..2147483000).
INT period_row=9.

```

```

FN l_32 = (l_input:in)  -->l_int32:ARITH in.
FN DV = (l_int32:a b)  -->l_int32:ARITH a%b.
FN PL = (l_int32:a b)  -->l_int32:ARITH a+b.
FN MI = (l_int32:a b)  -->l_int32:ARITH a-b.
FN TI = (l_int32:a b)  -->l_int32:ARITH a'b.

```

```

FN MSE_ROW = (l_input:a b)  -->l_int32:
BEGIN SEQ

```

```

    STATE VAR err INIT int320,
           count INIT int320;
    VAR diff:=int320,
        diff32:=int320;

```

```

    count:=count PL int32/1;

```

```

diff:=CASE count
  OF int32/(1..period_row)int32/0
  ELSE l_32(a) MI l_32(b)
  ESAC;
diff32:= (diff TI diff);
err:=err PL diff32;
OUTPUT (err, err DV count,count)
END.

FN PRBS10 = (l_reset:reset) ->{10}bool:
#A 10 bit prbs generator,feedback taps on regs 3 & 10.#
BEGIN
  MAKE [10]MYLATCH1,
  XNOR xor.

  FOR INT k=1..9 JOIN
    (reset,[k]) ->{[k+1]}.

  JOIN (reset,xor) ->{1},
    ([10],[3]) ->xor.

  OUTPUT 1
END.

FN PRBS11 = (l_reset:reset) ->{11}bool:
#A 11 bit prbs generator,feedback taps on regs 2 & 11.#
BEGIN
  MAKE [11]MYLATCH1,
  XNOR xor.

```

```

FOR INT k=1..10      JOIN
  (reset,[k])        ->[k+1].

JOIN  (reset,xnor)   ->[1].
      ([1],[2])      ->xnor.

OUTPUT  [1..10]

END.
COM
FN PRBS16 = (bool:reset) ->[16]bool:
#A 16 bit prbs generator,feedback taps on regs 1,3,12,16#
BEGIN
  MAKE [16]MYLATCH:1,
  XOR_4:xor,
  NOT:xnor.

FOR INT k=1..15      JOIN
  (ck,reset,[k])     ->[k+1].

JOIN  (ck,reset,xnor) ->[1].
      ([1],[3],[16],[12]) ->xor,
  xor ->xnor.
OUTPUT ([INT k=1..16][k])

END.
FN PRBS12 = (clock:ck,bool:reset) ->[12]bool:
#A 12 bit prbs generator,feedback taps on regs 1,4,6,12.#
BEGIN
  MAKE [12]MYLATCH:1,
  XOR_4:xor,
  NOT:xnor.

```

```

FOR INT k=1..11 JOIN
  (ck,reset,[k]) ->[k+1].

JOIN (ck,reset,xnor) ->[1].
  ([1],[4],[6],[12]) ->xor,
  xor ->xnor.
OUTPUT ([INT k=1..12][k])
END.

FN PRBS8 = (clock,rx,bool:reset) ->[8]bool:
#A 8 bit prbs generator, feedback taps on regs 2,3,4,8.#
BEGIN
  MAKE [8]MYLATCH1,
  XOR_4:xor,
  NOT:xnor.

FOR INT k=1..7 JOIN
  (ck,reset,[k]) ->[k+1].

JOIN (ck,reset,xnor) ->[1].
  ([2],[3],[4],[8]) ->xor,
  xor ->xnor.
OUTPUT ([INT k=1..8][k])
END.

MOC
#TEST FOR Y U V #
#to test the 2d convolver using prbs input into the forward convolver#
#then outputting to the inverse convolver and checking against the original result#

```

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```

FN TEST_COLOUR = (bool:ck,t_reset:reset,bool:extwrite|_in csl_in, t_sparc_addr:reg_sel value,t_reset:prbs_reset)
->{3}t_int32:

```

```

BEGIN

```

```

    FN DEL = (t_load:in) ->t_load:DELAY(read,1).

```

```

    FN PULSE = (t_load:in) ->t_reset:
    CASE (in,DEL in)
    OF (write,read):rst
    ELSE no_rst
    ESAC.

```

```

    MAKE PRBS11 prbs,
    BOOL_INT10:int_bool,
    DWT:dwt,
    [3]MSE_COLOUR:mse_cobur.

```

```

JOIN (CASE (prbs_reset,PULSE CASE dwt[3][2]

```

```

    OF write:read,
    read:write

```

```

    ESAC,PULSE CASE dwt[3][3]

```

```

    OF write:read,
    read:write

```

```

    ESAC,PULSE dwt[2][1],PULSE dwt[2][2],PULSE dwt[2][3])

```

```

    #return the prbs at start, or on out of IDWT#

```

```

OF (rst,t_reset,t_reset,t_reset,t_reset)((t_reset,rst,t_reset,t_reset,t_reset))
(t_reset,t_reset,rst,t_reset,t_reset)((t_reset,t_reset,t_reset,rst,t_reset))
(t_reset,t_reset,t_reset,t_reset,rst,t_reset)((t_reset,t_reset,t_reset,t_reset,rst)
ELSE no_rst
ESAC)
->prbs,

```



```

prbs      ->int_bool,
(ck,reset,int_bool,extwritel_in,cal_in,reg_sel,value)  ->dwt.

#calculate the mse error for each channel#
FOR INT j=1..3 JOIN
(CASE pwr[e][j])
OF read:ret
ELSE no_ret
ESAC,dwt[j](1,int_bool) ->mse_colour[j].
OUTPUT (mse_colour[1][1],mse_colour[2][1],mse_colour[3][1])
END.
FN DWT = (bool,t_reset,t_input,bool,bool,t_sparc_addr,reg_sel,value)  ->(t_input,[3]_load,[3]_load):IMPORT.
MAC PDEL(TYPE t,INT n) = (t) ->:IMPORT.

IMPORTS      dwt/siring: DWT_TEST( RENAMED DWT) PDEL.

#TEST FOR LUMINANCE ONLY#
#to test the 2d convolver using prbs input into the forward convolver#
#then outputting to the inverse convolver and checking against the original result#

FN TEST_Y = (bool:ck,t_reset:reset,bool:extwritel_in,cal_in,t_sparc_addr,reg_sel,value,t_reset:prbs_reset)
->[2]_int32:

BEGIN
  FN DEL = (t_load:in)  ->{_load:DELAY(read,1)}.
  FN PULSE = (t_load:in) ->{_reset:
    CASE (in,DEL in)

```

```

OF      (write,read):rst
ELSE    no_rst
ESAC.

MAKE PRBS11 prbs,
BOOL_INT10:int_bool,
DWT:dwt,
MSE_COLOUR:mse_colour.

JOIN    (CASE (prbs_reset,PULSE dwt[2][1])  #rerun the prbs at start, or on out of IDWT#
OF      (rst,1_reset))((1_reset,rst):rst
ELSE    no_rst
ESAC)
        ->prbs.

prbs    ->int_bool,
(ck,reset,int_bool,extwrite1_in,cal_in,reg_sel,value)  ->dwt,
(CASE dwt[2][1])
OF read:rst
ELSE no_rst
ESAC,dwt[1],int_bool) ->mse_colour.

OUTPUT mse_colour
END.

```

APPENDIX B-2

```

#test for abs #

FN ABS_TEST = (STRING(10)bit:in ln2) ->bool:ln LE_U in2.
#the state machine to control the address counters#
#only works for 3 octave decomposition ln y/2 ln ulv#

FN CONTROL_ENABLE = (bool:ck, l_reset:reset, l_channel:new_channel channel[3]bootc_blk, STRING(2)bit:subband,
  l_load:load_channel, l_mode:new_mode)

->((3)bool#en_blk#, l_octave,(2)bool#tree_done, lpf_block_done#, l_state#reset_state#):

BEGIN
  MAKE DF1(l_state):state.
  #set up initial state thro mux on reset, on HH stay in zz0 state#
  LET start_state = CASE channel
    OF ulv:down1,
      y:up0
    ESAC,
    reset_state= CASE reset
    OF rst: start_state
    ELSE state
    ESAC.

  LET next_values = (SEQ
    VAR en_blk:=3)!, #enable blk count#
    lpf_block_done:=1, #enable x_count for LPF#
    tree_done:=1, #enable x_count for other subbands#
    new_state:=reset_state,
    octave:=?l_octave; #current octave#

    CASE reset_state

```

```

ELSE
  ESAC),
  zz1: ( octave:=oct/0;
    en_blk[1]:=t
  CASE c_blk[1]
  OF t(new_state:=zz2;
    en_blk[2]:=q
  ELSE
    ESAC),
    zz2: ( octave:=oct/0;
      en_blk[1]:=t
    CASE c_blk[1]
    OF t(new_state:=zz3;
      en_blk[2]:=q
    ELSE
      ESAC),
      zz3: ( octave:=oct/0;
        en_blk[1]:=t
        CASE c_blk[1]
        OF t(new_state:=down1;
          en_blk[2]:=t; #roll over to 0#
          en_blk[3]:=t #because state zz3 clock 1 pulse#
        )
        ELSE
          ESAC
        ),
        down1: ( octave:=oct/1;
          en_blk[2]:=t
          CASE o_blk[2]

```

#now decide the next state, on block(1) carry check the other block carries#

```

OF up0: ( octave:=oct/2;
  en_blk[3]:=t;
  CASE c_blk[3]
  OF t:(CASE subband
    OF b'00':lpf_block_done:=t  #clock x_count for LPF y channel#
    ELSE new_state:=up1  #change state when count done#
    ESAC;

    CASE new_mode  #in luminance & done with that tree#
    OF stop:tree_done:=t
    ELSE
      ESAC)
    ELSE
      ESAC);
  up1: ( octave:=oct/1;
  en_blk[2]:=t;
  CASE c_blk[2]
  OF t:(new_state:=zz0;

    CASE new_mode  #in luminance, terminate branch & move to next branch#
    OF stop:(new_state:=down1;
      en_blk[3]:=t)
    ELSE
      ESAC)
    ELSE
      ESAC);
  zz0: ( octave:=oct/0;
  en_blk[1]:=t;
  CASE c_blk[1]
  OF t:(new_state:=zz1;
    en_blk[2]:=t)

```

```

OF t:(CASE subband
  OF b"00":lpf_block_done:=1  #clock x_count for LPF upv channel#
  ELSE new_state:=zz0  #change state when count done#
ESAC;

CASE (new_mode,channel)  #stop so finish this tree/branch & move on#
OF (stop,upv):tree_done:=1,
  (stop,y):(en_blk[3]:=t;
    CASE c_blk[3]  #move to next tree#
    OF tree_done:=1
    ELSE new_state:=down1
    ESAC
  )
ELSE
ESAC)
ELSE
ESAC)
ELSE
ESAC)

ESAC;

CASE channel
OF upr: CASE (c_blk[1],c_blk[2])
  OF (1,1):tree_done:=1
  ELSE
ESAC,
  y: CASE (c_blk[1],c_blk[2],c_blk[3])
  OF (1,1,1):tree_done:=1
  ELSE
ESAC

ESAC;

```

```

#now change to start state if the sequence has finished#
CASE free_done #in LPF state doesn't change when block done#
OF! new_state:= start_state
ELSE
ESAC;
#on channel change, use starting state for new channel#
CASE load_channel #in LPF state doesn't change when block done#
OF write: new_state:= CASE new_channel
OF!y:up0,
ulv:down1
ESAC
ELSE
ESAC;

OUTPUT (new_state,en_blk,oclave,(free_done,lpf_block_done))
).

JOIN (ck,next_values[1]) ->state.
OUTPUT (next_values[2],next_values[3],next_values[4],reset_state)
END.

FN CHECK = (t_inputx sub size y,t_oclave: ocl) -> t_sparc_addr:
ARITH ((x SL 1)+(1 AND sub) + size*(y SL 1) +(sub SR 1)))SL ocl.

#these are the addr gens for the x & y addresses of a pixel given the octave#
#sub&blk no. for each octave. Each x&y address is of the form #
# x= count(5 bits)(blk(3)..blk(oclave+1))(s) {octave 0's} #

```



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```

# y= count(5 bits){blk(3)..blk(octave+1)}{s} (octave 0's) #
#this makes up the 9 bit address for CIF images #
#the blk & s counters are vertical 2 bit with the lsb in the x coord #
#and carry out on 3, last counter is both horiz and vertical counter #
#read_enable enable the block count for the read address, but not the #
#carry-outs for the mode change, this is done on the write addr cycle #
#by write_enable, so same address values generated on read & write cycles#

FN ADDR_GEN = (bool:ck, t_reset:reset, t_channel:new_channel_channel, t_load:load_channel, STRING[2]bit:sub_count,
  STRING[xsize]bit:col_length, STRING[yssize]bit:row_length, STRING[xsize]bit:image_string,
  STRING[yssize]bit:image_string, STRING[1]bit:image_string, 3*ysize*2.5#,
  bool:read_enable, bool:write_enable, t_mode:new_mode)

-> (t_sparc_addr, t_octave, bool:sub_finished#, bool:tree_done#, bool:lpf_done#, t_state):
BEGIN
  MAKECOUNTER(xsize-4):x_count,
  COUNTER(yssize-4):y_count,
  CONTROL_ENABLE:control,
  [3]BLK_SUB_COUNT:blk_count.

#size of lpf images/2 -1, for y,uv. /2 because count in pairs of lpf values #
#lpf same size for all channels!!!#

LET (x_lpf, y_lpf) = (col_length[1..xsize-4], row_length[1..ysize-4]).

tree_done = control[3][1].
lpf_block_done = control[3][2].
x_en = CASE (tree_done, lpf_block_done)
  OF (t, bool) [(bool, i)]:
    ELSE 1
    ESAC,

```

```

blk_en=control[1],
octave=control[2],

```

#clk y\_count when all blocks done for subs 1-3, or when final blk done for ipif#

```

y_en = CASE sub_count
  OF b'00': CASE (ipf_block_done, x_count[2])
    OF (1,1):
      ELSE f
    ESAC
  ELSE CASE (iree_done, x_count[2])
    OF (1,1):
      ELSE f
    ESAC
  ESAC,

```

```

x_msb_out = CASE channel
  OF y: x_count[1] CONC B TO S(blk_count[3][1][2]), #always the msb bits#
    ulv: b'0' CONC x_count[1]
  ESAC,
y_msb_out = CASE channel
  OF yy_count[1] CONC B TO S(blk_count[3][1][1]),
    ulv: b'0' CONC y_count[1]
  ESAC,

```

```

x_lsb_out = CASE (octave) #bit2 is lsb#
  OF (oct0): (INT k=1..2) blk_count[3-k][1][2] CONC sub_count[2],
    (oct/1): (blk_count[2][1][2], sub_count[2], b'0),
    (oct/2): sub_count[2] CONC [2]b'0
  ESAC,

```

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```

y_lsb_out = CASE (octave) #bit 1 is msb#
OF (oct0):(INT k=1..2)blk_count[3-k][1]1)CONC sub_count[1],
  (oct1):(blk_count[2][1]1), sub_count[1], b'0),
  (oct2):sub_count[1]1)CONC [2]b'0
ESAC,
x_addr = x_msb_out CONC BIT_STRING(3)x_lsb_out,
y_addr = y_msb_out CONC BIT_STRING(3)y_lsb_out,

#enable the sub band counter#
sub_en = CASE (y_count[2],y_en)
OF (1,1):1
ELSE 1
ESAC,

lpt_done = CASE sub_count
OF b'00':sub_en #!!!!CHANGE ACCORDING TO LATENCY IN DECODE#
ELSE 1
ESAC,

base_y_sel = CASE channel
OF y1,
  u:c,
  v:r
ESAC,

base_rows = MUX_3(STRING(1)1b1)(ZERO(1)1b'0'.b'0' CONC yimage_string[1..ysize]CONC.b'0',
  yimage_string_3base_y_sel),
#base address for no of rows for y,u & v memory areas#

address = x_addr ADD_U ((y_addr ADD_U base_rows)[2..12]) MULT_U (CASE channel
  OF y:image_string,

```

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```

        upv:(SR_U(1)ximage_string)[1.xsize]
        ESAC)
    ).

    int_addr = (S_TO_SPARC_address)[2].

    JOIN (ck,reset_x_en,x_lpf)      ->x_count,
          (ck,reset_y_en,y_lpf)      ->y_count,
    #use new_channel so on channel change control state picks up correct value#
    (ck,reset_new_channel,channel,[INT]-1..3)blk_count([2]),sub_count,load_channel,new_mode)
    ->control.

    FOR INT k=1..3 JOIN (ck,reset_blk_en[k],read_enable OR write_enable,write_enable) ->blk_count[k].

    OUTPUT (int_addr,oclave,sub_en,tree_done,lpf_done,control[4])
    END.

    #a counter to control the sequencing of r/w, token, Huffman cycles#
    #decode reset is enabled 1 cycle early, and latched to avoid glitches#
    #lpf_slop is a dummy mode to disable the block writes&Huffman data#
    #cycles for that block#

    FN CONTROL_COUNTER = (boolck,1,resetreset,1,modemode,new_mode,1,direction,direction)
    ->(1,load,1,cycle,1,reset,bool,bool,load,1,cs,1,load,1,cs):

    #mode load,cycle,decode reset,read_addr_enable,write_addr_enable,load flags#
    #decode write_addr_enable early and latch to avoid feedback loop with pro_mode#
    #in MODE_CONTROL#
    BEGIN
        MAKE COUNT_SYNC(4):count.

```

```

LET count_len = (U_TO_LEN(4) count(1))|2;

LET out = (SEQ
  VAR cycle:=skip_cycle,
  decide_reset:=no_rst,
  load_mode:=read,
  load_flags:=read,
  cs_new:=no_select,
  cs_old:=select,
  rw_old:=read,
  read_addr_enable:=f,
  write_addr_enable:=f;

CASE direction
OF forward: CASE mode
  OF send|still_send|pl_send: CASE count_len
    OF len/(0..3):(read_addr_enable:=f;
      cs_new:=select),
      len/(4):(cycle:=token_cycle,
        load_flags:=write,
        write_addr_enable:=f),
      len/(5..7):(write_addr_enable:=f;
        CASE new_mode
        OF stop|pl_stop:(cycle:=skip_cycle;
          rw_old:=read;
          cs_old:=no_select),
          valid:(cycle:=skip_cycle;
            rw_old:=write)
        ELSE (cycle:=data_cycle;
          rw_old:=write)

```

```

        ESAC),
len/8:(decide_reset:=rst;
CASE new_mode
    OF stop|lpt_stop:(cycle:=skip_cycle;
        rw_old:=read;
        cs_old:=no_selected),
        void:(cycle:=skip_cycle;
            load_mode:=write;
            rw_old:=write)
    ELSE (cycle:=data_cycle;
        load_mode:=write;
            rw_old:=write)
        ESAC)
    ELSE
    ESAC,

still: CASE count_len
    OF len/(0..3):(read_addr_enable:=t;
        cs_new:=selected),
        len/(4):(cycle:=loken_cycle;
            write_addr_enable:=t;
            load_flags:=write),
        len/(5..7):(rw_old:=write;
            write_addr_enable:=t
        CASE new_mode
        OF void_still:(cycle:=skip_cycle
        ELSE cycle:=data_cycle
        ESAC),

len/8:(decide_reset:=rst;

```

```

rw_old:=write;
load_mode:=write;
CASE new_mode
OF  void_sll:cycle:=skip_cycle
ELSE cycle:=data_cycle
ESAC)

```

```

ELSE
ESAC,

```

```

hpf_still:

```

```

CASE count_len
OF len/0..3:(read_addr_enable:=t;
  cs_new:=select);
  len/4:(cycle:=token_cycle;
    write_addr_enable:=t;
    load_flags:=write);
  len/5..7:(cycle:=data_cycle;
    rw_old:=write;
    write_addr_enable:=t);
  len/8:(cycle:=data_cycle;
    rw_old:=write;
    decide_reset:=rst;
    load_mode:=write)
ELSE
ESAC,

```

```

void:

```

```

CASE count_len
OF len/0..3:(read_addr_enable:=t;
  cs_new:=select);
  len/4:(load_flags:=write;
    cycle:=token_cycle; #dummy token cycle for mode updates)

```

```

write_addr_enable:=1,
len/5..7:(write_addr_enable:=1, #keep counters going#
CASE new_mode
  OF
    stop:(rw_old:=read,
cs_old:=no_select)
  ELSE rw_old:=write
  ESAC),
len/8:(decide_reset:=rst;
CASE new_mode
  OF
    stop:(rw_old:=read,
cs_old:=no_select)
  ELSE (load_mode:=write;
rw_old:=write)
  ESAC)
ELSE
  ESAC,
void_still: CASE count_len
  OF len/0: write_addr_enable:=1, #allow for delay#
len/1..3:(write_addr_enable:=1;
rw_old:=write),
len/4:(rw_old:=write;
load_mode:=write;
decide_reset:=rst)
  ELSE
    ESAC
ELSE
  ESAC,

```

Inverse: CASE mode



```

OF send|still_send|!pf_send: CASE count len
  OF len/(0..3):(read_addr_enable=1).
    len/(4):(cycle:=token_cycle;
      write_addr_enable:=t;
      load_flags:=write);
    len/(5..7):(write_addr_enable:=t;
      CASE new_mode
        OF stop|!pf_stop:(cycle:=skip_cycle;
          rw_old:=read;
          cs_old:=no_select);
          void:(cycle:=skip_cycle;
            rw_old:=write)
        ELSE (cycle:=data_cycle;
          rw_old:=write)
        ESAC);
    len/8:(decide_reset:=rst;
      CASE new_mode
        OF stop|!pf_stop:(cycle:=skip_cycle;
          rw_old:=read;
          cs_old:=no_select);
          void:(cycle:=skip_cycle;
            load_mode:=write;
            rw_old:=write)
          ESAC)
      ELSE (cycle:=data_cycle;
        load_mode:=write;
        rw_old:=write)
      ESAC)
    ELSE
      ESAC,

```

```

still:      CASE count_len
            OF len/0):      #skip to allow reset in huffman
len/1):(cycle:=token_cycle;
            write_addr_enable:=1);
len/2..4):(rw_old:=write;
            write_addr_enable:=1;
            CASE new_mode
            OF void_still_cycle:=skip_cycle
            ELSE cycle:=data_cycle
            ESAC);

len/5:(rw_old:=write;
        decide_reset:=rst;
        load_mode:=write;
        CASE new_mode
        OF void_still_cycle:=skip_cycle
        ELSE cycle:=data_cycle
        ESAC)
        ELSE
        ESAC;
        CASE count_len
        OF len/0):      #match with previous
len/1):(      #skip for write end delay
            write_addr_enable:=1);
len/2..4):(cycle:=data_cycle;
            rw_old:=write;
            write_addr_enable:=1);
len/5:(cycle:=data_cycle;
        rw_old:=write;
        decide_reset:=rst;
        load_mode:=write)
    
```

```

ELSE
ESAC,
CASE count len
OF len/(0..3):(read_addr_enable:=1,
  len/4:(load_flags:=write;
  cycle:=token_cycle; #dummy token cycle for mode update#
  write_addr_enable:=1,
  len/5..7):(write_addr_enable:=1,
CASE new_mode
  OF stop:(rw_old:=read,
    cs_old:=no_select)
  ELSE rw_old:=write
  ESAC),
  len/8:(decide_reset:=rst;
CASE new_mode
  OF stop:(rw_old:=read,
    cs_old:=no_select)
  ELSE (load_mode:=write;
    rw_old:=write)
  ESAC)
ELSE
ESAC,
void_sht: CASE count len
  OF len/(0):. #match with res1#
  len/1:write_addr_enable:=1, #dummy as write delayed#
  len/(2..4):(write_addr_enable:=1,
    rw_old:=write),
  len/5: (rw_old:=write;
  load_mode:=write;
  decide_reset:=rst)
ELSE

```

```

ELSE
ESAC
ESAC;

```

```

OUTPUT (load_mode,cycle,DF1(!_reset)(ck,decide_reset),read_addr_enable,
DF1(bool)(ck_reset,write_addr_enable,1),load_flags,
cs_new,rw_old,cs_old)
).

```

```

JOIN (ck,CASE reset
OF rststl
ELSE out[3]
ESAC,1) ->count.

```

```

OUTPUT out
END.

```

```

#.....#
#A set of boolean ,ie gate level counters
#.....#

```

```

#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle ,outputs are q and tc (toggle for next counter)
#stage
#.....#

```

```

MAC BASIC_COUNT = (bool:ck,1,_reset:reset,bool:log) ->(STRING[1]ba,bool):

```

```

BEGIN
    MAKE DFF(boof:dlai,
    XOR xor,
    AND and.

    JOIN (ck,reset,xor,1)->dlai,
    (dlai,log) ->and,
    (log,dlai) ->xor.
    OUTPUT (CAST(STRING(1)bit) dlai,and)
END.

#.....#
# The n-bit macro counter generator, en is the enable, the outputs #
# are msb(bit 1)....lsb,carry. This is the same order as ELLA strings are stored#
#.....#

MAC COUNT_SYNC(INT n) = (boof:ck,1_reset:reset,boof:en)->(STRING(n)bit,boof):
(LET out = BASIC_COUNT(ck,reset,en).

    OUTPUT ( IF n=1
    THEN(out[1],out[2])
    ELSE (LET outh = COUNT_SYNC(n-1)(ck,reset,out[2]) .
    OUTPUT (outh[1] CONC out[1],outh[2])
    )
    F)

).
COM
FN TEST_COUNT_SYNC = (boof:ck,1_reset:reset,boof:en) -> ([4]boof,boof):
COUNT_SYNC(4)(ck,reset,en).
MOC

```

```
#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle, updown defines the direction, outputs are q and #
#tc (toggle for next counterstage, active low for down/high for up) #
#.....#
```

```
MAC BASIC_COUNT_UD = (bool:ck,1_reset:reset,bool:log,1_updown:updown) ->[2]bool:
```

```
BEGIN
    MAKE DFF(bool):dlat.
    LET  toggle = log.
    xorn = CASE updown
        OF up: CASE (toggle,dlat) #xor#
            OF (1,0)|(0,1)
                ELSE 1
            ESAC,
            down:CASE (toggle,dlat) #xor#
                OF (1,0)|(0,1)
                    ELSE 1
                ESAC
        ESAC,
    cout = CASE updown
        OF up:CASE (dlat,toggle) #AND#
            OF (1,0)
                ELSE 1
            ESAC,
            down:CASE (dlat,toggle) #OR#
                OF (1,0)
                    ELSE 1
                ESAC
```

ESAC.

```
JOIN (ck,reset,xom,l)->dlat.  
OUTPUT (dlat,cout)  
END.
```

```
#.....#  
# The n-bit macro w/d counter generator, en is the enable, the outputs #  
# are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#  
#first enable is active low on down, so invert. #
```

```
#.....#  
MAC COUNT_SYNC_UD(INT n) = (bool:ck,l_reset:reset,bool:en,l_updown:updown) ->(STRING[n]bit,bool):  
BEGIN
```

```
MAKE [n]BASIC_COUNT_UD(basic_count,
```

```
LET enable = (INT k=1..n-1) basic_count[k+1][2] CONC CASE updown #invert enable if down count#
```

```
OF up:en
```

```
ELSE NOT en
```

```
ESAC.
```

```
FOR INT k=1..n JOIN (ck,reset,enable[k],updown) ->basic_count[k].
```

```
OUTPUT (BOOL_STRING[n](INT k=1..n)basic_count[k][1],basic_count[1][2])
```

```
END.
```

COM

```
FN TEST_COUNT_SYNC_UD = (bool:ck,l_reset:reset,bool:en,l_updown:updown) ->([4]bool,bool):
```

```
COUNT_SYNC_UD(4)(ck,reset,en,updown).
```

MOC

```
#the basic x/y counter, carry out 1 cycle before final count given by x_lp/dy_lp#
```

```
MAC COUNT_SYNC_UD(INT n) = (bool:ck,l_reset:reset,bool:en,STRING[n]bitx_lpf) ->(STRING[n]bit,bool):
```

```
BEGIN
```

```

MAKE   COUNT_SYNC(n):x_count.

LET out = x_count[1].
final_count = out EQ_U x_lpf,
final_count_en=CASE (final_count,en)
OF (1,0):1
ELSE 1
ESAC,
#reset after 4 counts at final count value#
cnt_reset = CASE reset
OF rst:rst
ELSE CASE DFF1(boot)(ck,final_count_en) #reset taken out of DFF 12/6#
OF rst:rst
ELSE no_rst
ESAC
ESAC.
JOIN (ck,cnt_reset,en) ->x_count.
OUTPUT (out,final_count)
END.
COM
#the basic y counter, carry out 1 cycle before final count given by y_lpf#
#reset at end of channel given by system reset #
MAC Y_COUNTER = (boot,ck,1_reset,reset,boot,en,STRING(4)bit_y_lpf) ->(STRING(4)bit_boot):
BEGIN
MAKE   COUNT_SYNC(4):y_count.

LET out = y_count[1].
JOIN (ck,reset,en) ->y_count.
OUTPUT (out,out EQ_U y_lpf)

```



END.  
MOC

COM

#the blk, or sub-band counters, carry out on 3#

FN BLK\_SUB\_COUNT = (bool:ck,1\_resetreset, bool:en) ->(STRING[2]bit,bool):

BEGIN

MAKE COUNT\_SYNC[2]:blk\_count.

LET out = blk\_count[1].

JOIN (ck,reset,en) ->blk\_count.

OUTPUT(out,out EQ\_U (C\_TO\_S[2]cod[3])[2])

END.

MOC

#the blk, or sub-band counters, carry out on 3, cout\_en enables the carry out, & cin\_en AND en enables the count#

FN BLK\_SUB\_COUNT = (bool:ck,1\_resetreset, bool:en cin\_en cout\_en) ->(STRING[2]bit,bool):

BEGIN

MAKE COUNT\_SYNC[2]:blk\_count.

LET out = blk\_count[1].

JOIN (ck,reset,en AND cin\_en) ->blk\_count.

OUTPUT(out,(out EQ\_U (C\_TO\_S[2]cod[3])[2]) AND cout\_en)

END.

FN LAST\_BLK\_COUNT = (bool:ck,1\_resetreset, bool:en,1\_channel:channel,bool:line\_finished) ->

(STRING[2]bit,[2]boolfx\_en,y\_end):

BEGIN

MAKE BASIC\_COUNT : lsb msb.

JOIN (ck,reset,en) ->lsb,

(ck,reset,CASE channel

```

OF y:lsb[2],
u,v:line_finished
ESAC) ->msb.
LET out = (msb[1]CONCsb[1]).
OUTPUT (out, CASE channel
OF y:(out EQ_U (C_TO_S[2]cod/3)[2],line_finished),
u,v:(lsb[2],msb[2])
ESAC)
END.
#the L1 norm calculator/ comparison constants& flag values#
#adding 4 absolute data values so result can grow by 2 bits#
#5 cycle sequence, a reset cycle with no data input, followed#
#by 4 data cycles#
MAC L1NORM = (bool:ck, l_reset:reset, STRING(INT n)bit:in) ->STRING(n+2)bit:
BEGIN
MAKE DF1(STRING(n+4)bit):in2.
LET in_s = in,
msb = ALL_SAME(n)(B_TO_Sin_s[1]).
COM
add_in1 = ln2 CONC in_s[1], #in_s[1] is the carry in to the adder#
#lsb so gen carry to next bit#
add_in2 = ((in_s XOR_B msb)CONC in_s[1]),
#adder=ADD_U(add_in1,add_in2),#
MOC
add_in1 = (in_s XOR_B msb),
rst_mux = CASE reset
OF rst:ZERO(n+4)'0'
ELSE ln2

```

ESAC,

adder=ADD\_US\_ACTEL(adder\_in1,rst\_mux,CASE in\_s[1])

OF b'1:b'0

ELSE b'1

ESAC),

out=adder[2..(n+5)].

JOIN (ck,out) ->in2.

OUTPUT in2[3..n+4]

END.

#the block to decide if all its inputs are all 0#

FN ALL\_ZERO = (bool:ck, l\_reset:reset, l\_input:in) ->bool:  
BEGIN

MAKE DF1(bool):out.

LET in\_s = (IN\_TO\_S(input\_exp)in)[2].

in\_eq\_0 = in\_s EQ U\_ZERO(input\_exp)b'0', #in=0#

#1 if reset high, & OR with previous flag#

all\_eq\_0 = CASE reset

OF rst: in\_eq\_0

ELSE CASE out

OF H

ELSE in\_eq\_0

ESAC

ESAC.

```
JOIN (ck,all_eq_0)->out.
OUTPUT out
END.
```

```
MAC ABS_NORM = (bool:ck, 1_reset:reset, STRING(reset_exp-2)bit:qshift, STRING(int_nbit:n)
->(STRING(n+2)bit,bool:all <qshift/2):
```

```
BEGIN
```

```
MAKE DF-1(STRING(n+4)bit):n2,
```

```
DF-1(bool):out.
```

```
LET abs_in = ABS_S in,
```

```
rst_mux = CASE reset
```

```
OF rst:ZERO(n+4)bit
```

```
ELSE in2
```

```
ESAC,
```

```
adder = ADD_US_ACTEL(abs_in,rst_mux,bit),
```

```
add_s =adder[2..(n+5)],
```

```
in_small = abs_in LT_U qshift,
```

```
#1 if reset high, & OR with previous flag#
```

```
all_small = CASE reset
```

```
OF rst: 1
```

```
ELSE CASE in_small
```

```
OF H
```

```
ELSE out
```

```
ESAC
```

```
ESAC.
```

```
JOIN (ck,add_s) ->n2,
```

```
(ck,all_small) ->out.
```

```
OUTPUT (n2[3..n+4],out)
```

END.

```
#the decide fn block#
FN DECIDE = (boot:ck, l_reset:reset, l_result:q_hn, l_input:new_old, l_result_threshold_comparison,
             l_octave:ods, l_load:load_flags) ->[7]boot:
#nzflag,origin,notflag,ozflag,motion,pro_new_z,pro_no_z#
BEGIN
    MAKEL1NORM(input_exp): oz,
    ABS_NORM(input_exp): nz,
    ABS_NORM(input_exp+1):no,
    LATCH([7]boot):flags.
```

```
LET qshift=(l_TO_SC(result_exp)q_hn)[2][1..result_exp-2].
#divide by 4 as tests on coeff values not block values#
```

```
n_o=(lN_TO_S(input_exp)new)[2] SUB_S (lN_TO_S(input_exp)old)[2], #new-old, use from quant#
nzflag = nz[1] LE_U (l_TO_SC(result_exp)threshold)[2], #delay tests for pipelined data#
notflag = not[1] LE_U (l_TO_SC(result_exp)comparison)[2],
ozflag = oz EQ_U ZERO(input_exp)b'0',
origin = nz[1] LE_U not[1],
nz_plus_oz = nz[1] ADD_U oz,
```

```
pro_new_z = nz[2],
```

```
pro_no_z = not[2],
```

```
shift_add_sel = CASE DF (l_octave)(ck,ods) #delay ods to match pipelin delay#
OF ocd/ctuno,
```

```
ocd/1:dos,
ocd/2:tres,
ocd/3:quatro
ESAC,
```

```
#keep 13 bits here to match no, keep msb's#
```

```
shift_add = MUX_4[STRING[input_exp+3][bit]]      #delay ocds to match pipelin delay#
nz_plus_oz[1..input_exp+3],
b"0"CONC nz_plus_oz[1..input_exp+2],
b"00"CONC nz_plus_oz[1..input_exp+1],
b"000"CONC nz_plus_oz[1..input_exp],
shift_add_sel
),
```

```
motion = shift_add LE_U no[1],
```

```
#value for simulation#
```

```
nz_r = (SC_TO [(12) nz[1]] [2],
no_r = (SC_TO [(13) no[1]] [2],
oz_r = (SC_TO [(12) oz[2]],
sa_r = (SC_TO [(13) shift_add[2]],
```

```
JOIN (ck,reset,qshift,(IN_TO_S(input_exp)new)[2]) ->nz,
```

```
(load_flags,(nzflag,origln,noflag,ozflag,motion,pro_new_z,pro_no_z)) ->flags,
```

```
(ck,reset,qshift,CAST(STRING[input_exp+1][bit]n_o)->no,
```

```
(ck,reset,(IN_TO_S(input_exp)old)[2]) ->oz,
```

```
OUTPUT flags
```

```
END.
```

```
#the buffer for the FIFO#
```

```
#a pulse generator, glitch free#
```

```
FIN PULSE = (load:ck,1_reset:reset,1_load:h) ->1_load;
```

```

CASE (in_DFF(i_load)(ck,reset,in_read))
OF (write,read):write
ELSE read
ESAC.

```

```

#the length of the Huffman encoded word#
FN LENGTH = (i_inputmag_out) ->STRING[5]bit:
CASE mag_out #length of input coded word#
OF input/0:b"00001",
input/1:b"00011",
input/2:b"00100",
input/3:b"00101",
input/4:b"00110",
input/5:b"00111",
input/6:b"01000",
input/(7..21):b"01100"
ELSE b"10000"
# input/(22..37):b"10000"#
ESAC.

```

```

FN REV_BITS = (STRING[8]bit:n) ->STRING[8]bit:CAST(STRING[8]bit)(n[8],n[7],n[6],n[5],n[4],n[3],n[2],n[1]).

FN FIFO_BUFFER = (bool:ck,i_reset:reset,i_direction:direction,i_cycle:cycle,i_mode:mode,
i_input:value mag_out_huff, STRING[16]bit:fifo_in,i_fifo:fifo_full_fifo_empty,
STRING[32]bit:shift,STRING[2]bit:token_length,bool:flush_buffer,i_quant:qf_quant)

->(STRING[16]bit,STRING[16]bit,STRING[16]bit,STRING[5]bit,i_load,i_read):
#fifo_out,s,fifo_read fifo_write#

BEGIN
MAKEDFF_INT(STRING[16]bit:low_word_high_word,

```

```

DEF_INIT[STRING[5]bhl]:s.
DEF_INIT[1] high_low:high_low,
MUX_2[STRING[16]bhl]:high_in low_in high_out low_out.

```

```

LET dir_sel = CASE direction
OF forward:left
ELSE right
ESAC,

```

```

length = CASE cycle
OF token_cycle:b'000' CONC token_length,
skip_cycle:b'00000',
data_cycle: CASE mode #on LPF STILL length fixed, given by input_exp-shift const#
OF lpf_still:((LEN_TO_U[5] len(input_exp))[2] SUB_U
(Q TO U[3]) lpf_quant[2])[2..6]
ELSE LENGTH MUX_2[1] input[1]value, mag_out_huff, dir_sel)
ESAC
ESAC,

```

```

select_s = CASE direction
OF forward:b'0' CONC s[2..5]
ELSE s
ESAC,

```

```

new_s = (ADD_US_ACTEL(select_s,length,b'1))[2..6], #6 bits#
#if new_s pointer > 16#
#on inverse passed first 16 bits, active from [16,31] #
high_low_flag = new_s GE_U b'10000',

```



```
#forward#
fifo_not_full = CASE fifo_full
  OF ok_fifo: write
  ELSE read
  ESAC,
```

```
fifo_write = CASE high_low #type change#
  OF Nghtwrite
  ELSE CASE flush_buffer #flush buffer when frame finished#
    OF twrite #needs 2 cycles to clear#
    ELSE CASE DFFload)(ck,reset,flush_buffer,1)
      OF twrite
      ELSE read
      ESAC
    ESAC
  ESAC,
#from inverse#
```

```
data_ready = CASE fifo_empty
  OF ok_fifo: write
  ELSE read
  ESAC,
```

```
load_low = CASE reset #load low on reset to start things#
  OF rstwrite,
    no_rst: PULSE(ck,reset, CASE (high_low_flag,data_ready) #load low word#
      OF (write): write
      ELSE read
      ESAC)
```

```

ELSE read
ESAC,
#delay reset for s and load_high#
reset_s = DFF(l_reset)(ck,reset,reset,rsf),

```

```

load_high =CASE reset_s #load high next#
OF rstwrite,
no_rst:PULSE(ck,reset,CASE (high_low_flag,data_ready) #load high word#
OF (f.write).write
ELSE read
ESAC)
ELSE read
ESAC,

```

```

fifo_read = CASE load_low #read control for data_in FIFO#
OF write:read
ELSE CASE load_high
OF write:read
ELSE write
ESAC
ESAC,

```

#control signals#

```

(write_low,write_high) =CASE direction
OF forward:[2]fifo_not_full
ELSE (load_low,load_high)
ESAC,

```

```

(high_out_sel,low_out_sel) = CASE direction
OF forward:CASE high_low

```

OF high(left,right)  
ELSE (right,left)  
ESAC

ELSE [2]CAST0\_mud(0 GE\_U b\*10000)  
ESAC.

JOIN

(shift[17..32],fio\_in,dir\_set) ->high\_in,

(shift[1..16],fio\_in,dir\_set) ->low\_in,

(high\_word,low\_word,high\_out\_set) ->high\_out,

(low\_word,high\_word,low\_out\_set) ->low\_out,

(ck\_reset,write\_low,low\_in,ZERO(16)b\*0) ->low\_word,

(ck\_reset,write\_high,high\_in,ZERO(16)b\*0) ->high\_word,

(ck\_reset,fifo\_not\_full,CASE high\_low\_flag

OF t:high

ELSE low

ESAC,low)

->high\_low,

(ck,CASE forward

OF forward:reset

ELSE reset s

ESAC,CASE direction

OF forward:fifo\_not\_full

```
ELSE data_ready
    ESAC, new_s,ZERO(5)b'0') ->s.
```

```
OUTPUT (low_word,low_out,high_out,s,fifo_read,fifo_write)
END.
```

```
#the HUFFMAN decode/encode function#
```

```
#a pulse generator, glitch free#
```

```
FN PULSE = (bool:ck,l_reset,reset,l_load,in) ->l_load:
CASE (in,DFFn_load)(ck,reset,in,read)
OF (write,read):write
ELSE read
ESAC.
```

```
FN SHIFT32_16 = (STRING[32]bit:buffer,STRING[5]bit:s) ->STRING[16]bit:
#left justified value, s shift const#
```

```
BEGIN
LET shift = (s AND_B b'0111117)[2..5]. #input values rotated so always shift<16#
OUTPUT
CAST(STRING[16]bit)(INT j=1..16) MX16(CAST(STRING[16]bit)(INT i=1..16)buffer[j-1+i],shift))
END.
```

```
FN SHIFT16X16_32 = (STRING[16]bit:n, STRING[4]bit:sel) ->STRING[32]bit:
BEGIN
LET sel_mux4= CASE sel[1..2]
OF b'00':sel[3..4]
ELSE b'11'
```

4

```

MX16(CAST{STRING{16bit}}((INT i=1..15)n[16-i])CONC o[15],sel[1..4]).

MX16(CAST{STRING{16bit}}(INT i=1..16)n[17-i],sel[1..4]),

MX16(CAST{STRING{16bit}}(b0)CONC ((INT i=1..15)n[17-i]),sel[1..4]),
MX16(ZERO{2}b0)CONC CAST{STRING{14bit}}(INT i=1..14)n[17-i],sel[1..4]),
MX16(ZERO{3}b0)CONC CAST{STRING{13bit}}(INT i=1..13)n[17-i],sel[1..4]),
MX16(ZERO{4}b0)CONC CAST{STRING{12bit}}(INT i=1..12)n[17-i],sel[1..4]),

MX16(ZERO{5}b0)CONC CAST{STRING{11bit}}(INT i=1..11)n[17-i],sel[1..4]),
MX16(ZERO{6}b0)CONC CAST{STRING{10bit}}(INT i=1..10)n[17-i],sel[1..4]),
MX16(ZERO{7}b0)CONC CAST{STRING{9bit}}(INT i=1..9)n[17-i],sel[1..4]),
MX16(ZERO{8}b0)CONC CAST{STRING{8bit}}(INT i=1..8)n[17-i],sel[1..4]),

MUX_8bit(b0,n[16],n[15],n[14],n[13],n[12],n[11],n[10],CAST{[3]boolsel_mux8_high),
MUX_8bit(b0,b0,n[16],n[15],n[14],n[13],n[12],n[11],CAST{[3]boolsel_mux8_high),
MUX_8bit(b0,b0,b0,n[16],n[15],n[14],n[13],n[12],CAST{[3]boolsel_mux8_high),
MUX_8bit(b0,b0,b0,b0,n[16],n[15],n[14],n[13],CAST{[3]boolsel_mux8_high),

MX_4bit(b0,n[16],n[15],n[14],CAST{[2]boolsel_mux4_high),
MX_4bit(b0,b0,n[16],n[15],CAST{[2]boolsel_mux4_high),
MX_4bit(b0,b0,b0,n[16],CAST{[2]boolsel_mux4_high),

b0
)
END.

MAC_REV_4 = (STRING{4}bit:in) ->STRING{4}bit:CAST{STRING{4}bit}}(n[4],n[3],n[2],n[1]).

#in is data from bus, fifo_empty is input fifo control#
FN HUFFMAN_DECODE = (mode:mode,STRING{2}bit:token_length_in,STRING{32}bit:buffer,STRING{5}bit:s)

```

```

->(bit_1_input,STRING[2]bit#token#):
BEGIN
    MAKESHIFT32_16:input_decode.
COM
LET mag_out2 = CASE input_decode[9..12]
    OF b'1111':(input_decode[13..16] ADD_U b'10110') #add 22 to give value#
    ELSE input_decode[9..12] ADD_U b'00111' #add 7 to give value#
    ESAC,
MOC
LET sel_9_12 = CASE input_decode[9..12]
    OF b'1111'1
    ELSE 1
    ESAC,
mag_out2 = CASE sel_9_12
    OF 1:REV_4 input_decode[13..16]
    ELSE REV_4 input_decode[9..12]
    ESAC ADD_U
CASE sel_9_12
    OF 1: b'10110' #add 22 to give value#
    ELSE b'00111' #add 7 to give value#
    ESAC,
mag_out_huff = CASE input_decode[1]
    OF b'0:input/0
    ELSE CASE input_decode[3]
        OF b'1:input/1
        ELSE CASE input_decode[4]
            OF b'1:input/2
            ELSE CASE input_decode[5]
                OF b'1:input/3

```

```

ELSE CASE input_decode[6]
OF b'1:input/4
ELSE CASE input_decode[7]
OF b'1:input/5
ELSE CASE input_decode[8]
OF b'1:input/8
ELSE (S_TO_IN (b'0000' CONC mag_out2))[2]
ESAC
ESAC
ESAC
ESAC
ESAC
ESAC,

```

```

#on lpf still bit 1 is the sign bit#
sign = CASE mode
OF lpf still:input_decode[1]
ELSE CASE mag_out_huff
OF input/b'0
ELSE input_decode[2]
ESAC
ESAC,

```

```

#select huff value, 0 (in lpf_send) or real value, rearrange the bits for real data#
#on lpf still bit 1 is sign bit so discard#
mag_out = CASE mode
OF lpf still:(S_TO_IN (CAST(STRING[9]b))[INT j=1..9]input_decode[11-10])[2]
ELSE mag_out_huff
ESAC,

```



```

token_length = b'000'CONC token_length_in,

#decode token, valid only during a token cycle#
token = CASE token_length{4..5}
  OF b'10':input_decode{1..2},
    b'01':input_decode{1} CONC b'0'
  ESAC.

JOIN (buffer,s) ->input_decode.

OUTPUT (sign,mag_out,token)
END.

#the huffman encoder#
FN HUFFMAN_ENCODE = (l_input_value,b1:sign,STRING{2}bit:token,l_mode:mode,l_cycle:cycle,
  STRING{16}bit:buffer,STRING{5}bit:s
  ->{STRING{32}bit}):
BEGIN
  MAKE SHIFT16X16_32shift
  #encode value#
  LET header = CAST(STRING{2}bit)(b'1,sign).

  value_bit = CAST((16bit)(IN_TO_S(16) value){2},
    sub_const = CASE value
      OF input/(7..21):b'00111',
        input/(22..37):b'10110'
      ELSE b'00000'
    ESAC,

```

sub\_value = ((IN\_TO\_S(input\_exp)value)[2] SUB\_U sub\_const)[8..1],

enc\_value =

CASE cycle

OF token\_cycle: token CONC ZERO(14)b'0', #token is msb, max 2 bits#

data\_cycle: CASE mode

#on intra & LPF pass thru value as 16 bit word, and reverse bit order, place sign first next to lsb#

OF lpf\_slli: CAST(STRING(1)bit) sign CONC CAST(STRING(15)bit) ((INT j=1..15) value\_bit(17-j))

#otherwise value is to Huffman encoded, so out 16 bit as this is the max, the slli removes the extra bits#

ELSE CASE value

OF input/0: b'0' CONC ZERO(15)b'0',

input/1: header CONC b'1' CONC ZERO(13)b'0',

input/2: header CONC b'01' CONC ZERO(12)b'0',

input/3: header CONC b'001' CONC ZERO(11)b'0',

input/4: header CONC b'0001' CONC ZERO(10)b'0',

input/5: header CONC b'00001' CONC ZERO(9)b'0',

input/6: header CONC b'000001' CONC ZERO(8)b'0',

input/(7..21): header CONC b'0000000' CONC (REV\_4 sub\_value) CONC ZERO(4)b'0', #sub 7 to give value#

input/(22..37): header CONC b'00000001111' CONC (REV\_4 sub\_value) #sub 22 to give value#

ELSE header CONC b'0000000111111111'

ESAC

ESAC,

skip\_cycle: ZERO(16)b'0' #dummy value#

ESAC.

```
JOIN (buffer,enc_value,s[2..5]) ->shift.
```

```
#max value is 37 so 8 bits enough#  
OUTPUT shift  
END.
```

```
# some basic macros for the convolver, assume these will#  
#be synthesised into leaf cells#
```

```
MAC MX_4(TYPE ty)=(ty:in1 in2 in3 in4, [2]boot:sel) ->ty:
```

```
CASE sel  
OF (1,0):in1,
```

```
(1,1):in2,
```

```
(1,0):in3,
```

```
(1,1):in4
```

```
ESAC.
```

```
MAC ENCODE4_Z = (1_mux4:in) ->[2]boot:
```

```
CASE in
```

```
OF uno:(1,0),
```

```
dos:(1,1),
```

```
tres:(1,0),
```

```
quatro:(1,1)
```

```
ESAC.
```

```
MAC ENCODE3_2 = (1_mux3:in) ->[2]boot:
```

```
CASE in
```

```
OF t:(1,0),
```

```
c:(1,1),
```

r:(1,0)  
ESAC.

MAC\_MUX\_3(TYPE i)=(i:in1 in2 in3, l\_mux3:sel) -> l:  
MX\_4(i)(in1,in2,in3,in1,ENCODE3\_2 sel).

MAC\_MUX\_4(TYPE i)=(i:in1 in2 in3 in4, l\_mux4:sel) -> l:  
MX\_4(i)(in1,in2,in3,in4,ENCODE4\_2 sel).

MAC\_MUX\_2(TYPE i)=(i:in1 in2, l\_mux2:sel) -> l:  
CASE sel  
OF left:in1,  
right:in2  
ESAC.

MAC\_MUX\_8(TYPE i)=(i:in1 in2 in3 in4 in5 in6 in7 in8, [3]bodi:sel) -> ly:  
CASE sel  
OF (1,1,0):in1,  
(1,1,0):in2,  
(1,1,0):in3,  
(1,1,0):in4,  
(1,1,0):in5,  
(1,1,0):in6,  
(1,1,0):in7,  
(1,1,0):in8  
ESAC.  
MAC MX16=(STRING[16]bit:in, STRING[4]bit:sel) -> bit:  
CASE sel  
OF b"0000":in[1],  
b"0001":in[2],

```
b*0010*:in[3],
b*0011*:in[4],
b*0100*:in[5],
b*0101*:in[6],
b*0110*:in[7],
b*0111*:in[8],
b*1000*:in[9],
b*1001*:in[10],
b*1010*:in[11],
b*1011*:in[12],
b*1100*:in[13],
b*1101*:in[14],
b*1110*:in[15],
b*1111*:in[16]
ESAC.
COM
MAC MX16=(STRING[16]bit:n, STRING[4]bit:sel) ->bit:
MUX_2(bit)(
MUX_8(bit)(in[1],in[2],in[3],in[4],in[5],in[6],in[7],in[8],CAST([3]bool)sel[2..4]),
MUX_8(bit)(in[9],in[10],in[11],in[12],in[13],in[14],in[15],in[16],CAST([3]bool)sel[2..4]),
CASE sel[1]
OF b0:left
ELSE right
ESAC).
MOC
MACINT_BOOL=(!_quant:c) ->[3]bool:
CASE q
OF quant/0:(f,f,f),
quant/1:(f,f,f),
quant/2:(f,f,f).
```

quant/3:(1,1,1).  
quant/4:(1,1,1).  
quant/5:(1,1,1).  
quant/6:(1,1,1).  
quant/7:(1,1,1)  
ESAC.

COM  
MAC\_MUX\_3(TYPE i)=(i:n1 n2 n3, l\_mux3:sel) -> i:  
CASE sel  
OF i:n1,  
c:n2,  
r:n3  
ESAC.

MAC\_MUX\_4(TYPE i)=(i:n1 n2 n3 n4, l\_mux4:sel) -> i:  
CASE sel  
OF uno:n1,  
dos:n2,  
tres:n3,  
quatro:n4  
ESAC.  
MOC

FN NOT = (bool:n) -> bool: CASE in OF t,f,h ESAC.

FN XOR = (bool: a b) -> bool:  
CASE (a,b)  
OF (1,1),(1,0),  
ELSE 1  
ESAC.

```

FN AND = (bool: a b) ->bool:
CASE (a,b)
OF (1,1):f,
   ((bool)((bool,0):f
ESAC.

```

```

FN OR = (bool: a b) ->bool:
CASE (a,b)
OF (1,0):f,
   ((bool)((bool,0):1
ESAC.

```

```

MAC DEL(TYPE i) = () ->t:DELAY(?,1).

```

```

#a general d latch#
MAC LATCH (TYPE i)=(i_load:load,i_in) ->t:
BEGIN
  MAKE DEL(i):del.
  LET out=CASE load
    OF write:in
      ELSE del
    ESAC.
  JOIN out->del.
  OUTPUT out
END.

```

```

#a general diff#
MAC DF1 (TYPE i)=(bool:ck,i_in) ->t:
BEGIN
  MAKE DEL(i):del.

```

```
JOIN in->del.  
OUTPUT del  
END.
```

```
#a resetable DFF, init value is input parameter  
MAC DFF_INIT(TYPE l)=(bod:ck,l_reset:reset,l_load:load,l_in init_value) ->t  
BEGIN  
  MAKE DEL(l):del.  
  LET out=CASE (load,reset)  
    OF (write,l_reset):in,  
       (read,rst):init_value  
    ELSE del  
    ESAC.  
  JOIN out->del.  
  OUTPUT CASE reset  
    OF rst:init_value  
    ELSE del  
    ESAC  
  END.
```

```
#a diff resetable non-loadable dff  
MAC DFF(TYPE l)=(bod:ck,l_reset:reset,l_in init_value) ->t:  
BEGIN  
  MAKE DEL(l):del.  
  JOIN in->del.  
  OUTPUT CASE reset  
    OF rst:init_value  
    ELSE del  
    ESAC  
  END.
```



```

MAC PDEL(TYPE i,INT n) = (i:in) -> t;
IF n=0 THEN DEL(i)n
ELSE PDEL(i,n-1) DEL(i) n
FI.

```

```

MAC PDF1(TYPE i,INT n) = (bool:ck,i:in) -> t;
IF n=0 THEN DF1(i)(ck,in)
ELSE PDF1(i,n-1)(ck,DF1(i)(ck,in))
FI.

```

#generates the new\_mode from the old, and outputs control signals to the tokeniser#

```

FN MODE_CONTROL = (bool:ck, i_reset:reset, i_intra:intra_inter, bool:ipf_done,[7]bool:flags,
STRING[2]bit:token_in,i_octave:octave,i_state:state,i_direction:direction,i_load:load_mode_in
,i_cycle:cycle)
-> (i_mode,i_mode,STRING[2]bit,i_diff,STRING[2]bit,i_mode);
#new_mode,proposed mode,current token,difference,token_length, #
BEGIN

```

```

MAKE [4]DF1 INIT(i_mode):mode,
DF1 INIT(i_diff:diff_out,
DF1 INIT(i_mode):next_mode.
LET nzflag=flags[1],
origIn=flags[2],
noflag=flags[3],
ozflag=flags[4],
motion=flags[5],
pio_new_z = flags[6],
pio_no_z = flags[7].

```

```

lpf_done_del = DFF{bool}(ck.reset,lpf_done,0).      #synchronise mode change at end of LPF#
LET next = (SEO
#the proposed value for the mode at that octave, flags etc will change this value as necessary#
#proposed, or inherited mode from previous tree#

```

```

VAR pro_mode:= CASE reset
  OF rst:CASE htra_inter   #reset on frame start, so do lpf#
    OF htra:lpf_still
      ELSE lpf_send
        ESAC
    ELSE CASE lpf_done_del
      OF t:CASE htra_inter   #store default mode in mode[4]#
        OF intra:still
          ELSE send
            ESAC
        ELSE CASE state
          OF down1:mode[3], #jump sideways in ocd/1#
            up0:mode[4]
          ELSE CASE octave
            OF ocd/0:mode[1],
              ocd/1:mode[2],
              ocd/2:mode[3]
              ESAC
            ESAC
          ESAC
        ESAC
      new_mode:=pro_mode,      #inherit the previous mode#
      token_out:=b"00",

```

```

difference:=nodif,
token_length:=b'00',
flag:=f,
CASE direction
OF forward:

```

```

CASE pro_mode
OF void:CASE ozflag
OF l:new_mode:=stop
ELSE
ESAC,      #stay in these modes until end of tree#

```

```

void_still:,      #intra so must zero out all of tree#

```

```

still_send:(token_length:=b'01';
CASE (nzflag OR pro_new_z)
OF t:(token_out:=b'00';
CASE ozflag
OF l:new_mode:=stop
ELSE new_mode:=void
ESAC)
ELSE (token_out:=b'10';
new_mode:=still_send)
ESAC
).

```

```

send: CASE ozflag
OF t:(token_length:=b'01';

```

```

CASE (nzflag OR pro_new_z)

```

```

OF t:(token_out:=b'00';
    new_mode:=stop)
ELSE (token_out:=b'10';
    new_mode:=still_send)
ESAC
)
ELSE (token_length:=b'10';

CASE (NOT noflag OR motion) AND NOT nflag)
OF t(CASE origin
    OF lflag:=pro_new_z
    ELSE (flag:=pro_no_z;
        difference:=diff)
    ESAC;
CASE flag
OF t:(token_out:=b'10';
    new_mode:=void)
ELSE CASE origin
    OF t:(token_out:=b'01';
        new_mode:=still_send)
    ELSE (token_out:=b'11';
        new_mode:=send)
    ESAC
ESAC)
ELSE
CASE (motion OR origin) AND nflag
OF t:(token_out:=b'10';
    new_mode:=void)
ELSE (token_out:=b'00';
    new_mode:=stop)

```

```

        ESAC
      )
    ESAC,

```

```

still: (token_length=b'01';
CASE (nzflag OR pro_new_z)
OF:(token_out=b'00';
      new_mode:=void_still) #zero out tree#
ELSE (token_out=b'10';
      new_mode:=still)
ESAC
),

```

```

(pf_still):(token_out=b'00';      #for ELLA only DUMB!!#
  token_length=b'00'),
(pf_send):(difference:=diff;
  token_length=b'01';

```

```

CASE (noflag OR pro_no_z)
OF  t:(token_out=b'00';
      new_mode:=pf_stop)
ELSE (token_out=b'10';
      new_mode:=pf_send) #as mode stop but for this block only#
ESAC)
ESAC,

```

```

inverse:
CASE pro_mode

```

```

OF void: CASE ozflag
  OF t:new_mode:=stop
  ELSE
  ESAC,

```

```

void_still: .

```

```

send: CASE ozflag
  OF t:(token_length:=b'01';  #repeat of still-send code#
  CASE token_ln[1])
  OF  b'1:new_mode:=still_send,
  b'0:new_mode:=stop
  ESAC
  )

```

```

ELSE (token_length:=b'10';
CASE token ln
  OF b'11': (difference:=diff;
  new_mode:=send),
  b'01':new_mode:=still_send,
  b'10':new_mode:=void,
  b'00':new_mode:=stop
  ESAC
  )
ESAC,

```

```

still_send: (token_length:=b'01';
CASE token_ln[1])
  OF b'1:new_mode:=still_send,
  b'0: CASE ozflag
  OF t:new_mode:=stop

```

```

ELSE new_mode:=void
ESAC
).
still: (token_length:=b'01';
CASE token_h[1]
OF b'1:new_mode:=still,
b'0:new_mode:=void_still
ESAC
).
(pf_send):(difference:=diff;
token_length:=b'01';
CASE token_h[1]
OF b'0:new_mode:=pf_stop,
b'1:new_mode:=pf_send
ESAC,
pf_still:
ESAC
ESAC;

OUTPUT (new_mode,pro_mode,token_out,difference,token_length)
).
LET load_mode = CASE (reset,pf_done_del) #store base mode in mode[3]& mode[4], base changes after pf#
OF (rst,boof)[1:reset,1):(read,read,write,write)
ELSE CASE (octave,load_mode_in)

```

```

      OF (oct1,write):(write,write,read,read),
        (oct2,write):(read,write,write,read)
      ELSE (read,read,read,read)
      ESAC
    ESAC.
  #save the new mode& difference during a token cycle, when the flags and tokens are valid#
  JOIN (ck,reset,CASE cycle
    OF token_cycle:write
      ELSE read
      ESAC, next[1],still) ->next_mode,

    (ck,reset,CASE cycle
      OF token_cycle:write
        ELSE read
        ESAC, next[4],modified) ->diff_out.

  #now write the new mode value into the mode stack at end of cycle, for later use #
  FOR INT 1=1..4 JOIN (ck,no_rst,load_mode[i],CASE (reset,lpf_done_def)
    OF (no_rst,1)((rst,bool):next[2]
      ELSE next_mode
      ESAC,still) ->mode[i].
  #dont update modes at tree base from lpf data, on reset next[1] is undefined#

  OUTPUT (next_mode,next[2],next[3],diff_out,next[5],next[1])
  END.

  #the tree coder chip#
  #threshold = 2^quant_norm#

  FN PALMAS= (bool:ck,1_reset:reset,1_direction:direction,1_intra:intra_inter,1_channel_factor:channel_factor,

```



```

[4] quant:quant norm, STRING[16]bit:buffer in,
i input:new old,[4] result:threshold, i fifo:full fifo empty, STRING[size]bit:col_length,
STRING[size]bit:row_length, STRING[size]bit:ximage_string, #ximage#
STRING[size]bit:yimage_string, STRING[1]bit:yimage_string_3#yimage& yimage*2.5#)

->(i input,i spare_addr,(i load,i cs),(i load,i cs),STRING[16]bit,[2]i load,bool,i cycle):

#old,address,(rw_new,cs_new),(rw_old,cs_old),buffer_out,fifo_read,fifo_write,cycle#

BEGIN
MAKEDECIDE:decide,
ADDR_GEN:addr_gen,
HUFFMAN_ENCODE:huffman_encode,
FIFO_BUFFER:fifo_buffer,
HUFFMAN_DECODE:huffman_decode,
MODE_CONTROL:mode,
CONTROL_COUNTER:control_counter,
BLK_SUB_COUNT:sub_count,
DEF_INIT(i_channel):channel,
QUANT:quant.

```

LET

```

nzflag=decide[1],
origln=decide[2],
noflag=decide[3],
ozflag=decide[4],
motion=decide[5],
pro_no_z = decide[7], #pro_no_z or pro_new_z#
pro_new_z = decide[6],

```

```
new_mode = mode[1].
pro_mode = mode[2].
token_out = mode[3].
difference = mode[4].
token_length = mode[5].
```

```
pro = quant[1], #pro no, or pro_new#
lev_out = (S_TO_IN quant[2])[2], #corresponding level#
sign = quant[3], #end sign #
```

```
ocds = addr_gen[2].
sub_en = addr_gen[3].
tree_done = addr_gen[4].
lpl_done = addr_gen[5].
state = addr_gen[6].
```

```
cycle = control_counter[2].
cs_new = control_counter[7].
rw_new = read.
rw_old = control_counter[8].
cs_old = control_counter[9].
```

```
load_channel = CASE (sub_en, sub_counter[2]) #change channel#
  OF (1,1):write
  ELSE read
  ESAC.
```

```
new_channel = CASE channel_factor
  OF luminance: y
  ELSE CASE channel
    OF y-u,
```

```

        u.v,
        v.y
        ESAC,
        ESAC,
        #flush the buffer in the huffman encoder#
        flush_buffer = DFF(bool)(ck_reset, CASE channel_factor
        OF luminance: CASE load_channel
        OF write: 1
        ELSE 1
        ESAC,
        color: CASE (channel, load_channel)
        OF (v, write): 1
        ELSE 1
        ESAC
        ESAC, 1),

frame_done = PDF1(bool, 1)(ck_flush_buffer),

fifo_write = fifo_buffer[6],
fifo_read = fifo_buffer[5],
s = fifo_buffer[4],

buffer_out = fifo_buffer[1],

lev_in = huffman_decode[2],
sign_in = huffman_decode[1],
token_in = huffman_decode[3],

del_new = PDF1(_input, 4)(ck_new),

```

```

#old has variable delays for inverse#
del_old = CASE (direction,pro_mode)
  OF ((forward,1_mode))((inverse,send|still_send|prf_send|vold):PDF1((input,4)(ck,old)
  ELSE PDF1((input,1)(ck,old)
  ESAC,
decide_reset=CASE reset
  OF rstrst
  ELSE ctrlrd_counter[3]
  ESAC,

ocd_sel = CASE pro_mode
  OF|prf_still|prf_send|prf_stop:qualtro
  ELSE CASE (ocds,channel)
    OF (ocd/0,y):uno,
      (ocd/1,y)((ocd/0,u|v):dos,
      (ocd/2,y)((ocd/1,u|v):tres
    ESAC
  ESAC,

lthreshold_ocd = MUX_4((result)(lthreshold[1],lthreshold[2],lthreshold[3],ltheshold[4],ocd_sel),
quant_ocd = MUX_4((quant_norm[1],quant_norm[2],quant_norm[3],quant_norm[4],ocd_sel).
JOIN (ck,decide_reset,lthreshold_ocd,new,old,lthreshold_ocd,lthreshold_ocd,ocds,ctrlrd_counter[6])->decide,
(ck,reset,ltra_ltra_lprf_done,decide,token_in,ocds,state,direction,ctrlrd_counter[1],cycle)->mode,
#delay the new&old values by 5 or 1 depending on mode & direction#
((IN_TO_S(input_exp|del_new)[2],(IN_TO_S(input_exp|del_old)[2],
((IN_TO_S(input_exp|lev_in)[2],sign_in,direction,quant_ocd,difference,pro_mode) ->quant,

```

```

(ck,reset,new_channel,channel,load_channel,sub_count[1],col_length,row_length,
ximage_string,yimage_string,yimage_string_3,control_counter[4],control_counter[5],new_mode)->addr_gen,

(ck,reset,direction,cycle,pro_mode,lev_out,huffman_decode[2],buffer_in,fifo_full,
fifo_empty,huffman_encode,token_length,flush_buffer,quant_norm[4])      ->fifo_buffer,

(lev_out,sign,token_out,pro_mode,cycle,fifo_buffer[2],s)      ->huffman_encode,

(pro_mode,token_length,fifo_buffer[2] CONC fifo_buffer[3],fifo_buffer[4])      ->huffman_decode,

(ck,reset,sub_en,1,1)      ->sub_count,

(ck,reset,pro_mode,new_mode,direction)      ->control_counter,

(ck,reset,load_channel,new_channel,y)      ->channel.
OUTPUT

(CASE new_mode
OF void|void still:input/0
ELSE (S_TO_INpro)[2]
ESAC      .addr_gen[1],(rw_new,cs_new),(rw_old,cs_old),buffer_out,(fifo_read,fifo_write),frame_done,cycle)
END.
COM
#the decoder for the barrel shifter-- decides if the bit value and q value are #
#in the upper-triangle, or diagonal and set the control bits      #

MAC DECODE(INT n) = (i_quant;q) ->[qmax](bool#upper diag# bool#diagonal#):
BEGIN
#one bit of the decoder#
MAC DECODE_BIT(INT j) = (i_quant;q) ->[bool,bool]:
CASE q

```

```

OF quant/(0.qmax-1):(1,0), #upper triangle#
  quant/(qmax-1+1):(1,1) #diagonal#
ELSE (1,0)
ESAC.
OUTPUT((INT j=1..qmax)DECODE_BIT(j)(q))
END.

```

```

#now the selector fn to mux between the data in bit_0 or 1 depending on q#
MAC_SELECTOR = (1_quant;q,STRING(INT n|bit:data)

```

```

->(STRING(n|bit#level#,STRING(n|bit#round_level#):

```

```

BEGIN

```

```

  #the 3->2 bit selector#

```

```

  MAC_SELECT_BIT = (2|bool:upper_or_diag,bit:data)    ->(bit,bit):#level[j],round_level[j]#

```

```

  CASE upper_or_diag

```

```

    OF (1,0):(data,data), #upper-triangle#

```

```

      (1,1):(b'0,b'0) #diagonal#

```

```

    ELSE (b'0,b'1) #lower-triangle#

```

```

  ESAC.

```

```

  MAKE DECODE(n):decode,

```

```

    [qmax]SELECT_BIT:select.

```

```

  JOIN (q) ->decode.

```

```

FOR INT j=1..qmax JOIN (decode[j],data[n-qmax+1]) ->select[j].

```

```

OUTPUT (data[1..n-qmax] CONC (BIT_STRING(qmax)((INT j=1..(qmax)select[j][1]), #level#

```

```

  data[1..n-qmax] CONC (BIT_STRING(qmax)((INT j=1..(qmax)select[j][2]) ) #round_level#

```

```

)

```

```

END.

```

```

MOC

```

```

#now the selector fn to split the level depending on q#

```

```

MAC BARREL_SHIFT_RIGHT = (1_quant:q,STRING(INT n)bit:data) -> (STRING(n)bit#level#):
MUX_8(STRING(n)bit){
  data,
  b'0'CONC data[1..n-1],
  b'00'CONC data[1..n-2],
  b'000'CONC data[1..n-3],
  b'0000'CONC data[1..n-4],
  b'00000'CONC data[1..n-5],
  b'000000'CONC data[1..n-6],
  b'0000000'CONC data[1..n-7],
  INT_BOOL q.

```

```

#the bsbit for the inverse, to generate the rounded level #
MAC BARREL_SHIFT_LEFT = (1_quant:q,STRING(INT n)bit:data#lev#) -> (STRING(n)bit#round_level#):
MUX_8(STRING(n)bit){
  data,
  data[2..n]CONCb'0',
  data[3..n]CONCb'01',
  data[4..n]CONCb'011',
  data[5..n]CONCb'0111',
  data[6..n]CONCb'01111',
  data[7..n]CONCb'011111',
  data[8..n]CONCb'0111111',
  INT_BOOL q.

```

#the function to return the quantised level(UNSIGNED), and proposed value given, #  
 # the new&old values, forw/inverse direction #

```

FN QUANT = (STRING(input_exp)bit: new old lev Inv,bit:sign_lev Inv,1_direction:direction,1_quant:q,1_diff:difference,
1_mode:mode)

```

BEGIN

-> (STRING(input\_exp)bi,STRING(input\_exp)bi) #pro,lev& sign# :

LET

#decide which of new-old or new will be quantised, and the sign of the level#  
#level is stored in sign & magnitude form#

dir\_sel = CASE direction  
OF forward:left,  
inverse:right  
ESAC,

sub\_sel = CASE difference  
OF diff:left  
ELSE right #put old=0#  
ESAC,

sub\_in= MUX\_2(STRING(input\_exp)bi)(old,ZERO(input\_exp)bi,sub\_sel).

no=ADD\_SUB\_ST(new,sub\_in,sub).

lev\_final=ABS\_S no, #now input\_exp+1 bits#

sgn\_level = MUX\_2(bi) (#sign of value to be quantised#  
no(!),  
sign\_lev\_inv,  
dir\_sel).



#find the quanti. level by shifting by q, for the inverse it comes from the Huffman decoder#

LET

lev\_data = BARREL\_SHIFT\_RIGHT(q,lev\_final).

#satulate the lev at 37, for the Huffman table,except in lpf\_slll mode, send all the bits#

lev\_forw = CASE mode

OF lpf\_slll:lev\_data

ELSE CASE lev\_data GT\_U b'00000100101'

OF: b'00000100101'

ELSE lev\_data

ESAC

ESAC,

lev = MUX\_2(STRING[input\_exp+1]b'1') (

lev\_forw,

b'0' CONC lev\_inv,

dlr\_sel).

#the level = 0 flag#

lev\_z = lev EQ\_U ZERO[input\_exp+1]b'0'.

inv\_lev\_z = CASE lev\_z

OF tb'0

ELSE b'1

ESAC,

#the level value shifted up, and rounded#

round\_lev = BARREL\_SHIFT\_LEFT(q,lev) AND\_B

CASE mode

OF lpf\_slll: b'00' CONC ALL SAME[input\_exp-1]b'1'

ELSE BIT\_STRING[input\_exp+1]([input\_exp+1]inv\_lev\_z) #if lev==0 out all 0's#

ESAC,  
#clear out extra bit for ipd\_sllt case#

#calculate the proposed value: in the case n=0, round\_lev is unsigned 10 bit, so result needs 11 bits#  
#pro\_no will always be in range as round\_lev<|n-o| #

pro\_no = ADD SUB\_ST(odd round\_lev, CASE sgn\_level  
OF b0: add,  
b1: sub,  
ESAC),

#now pro\_new = +/- round\_lev#

round\_sel = CASE sgn\_level  
OF b0: left,  
b1: right  
ESAC,

pro\_new = MUX\_2(STRING[input\_exp+1]bit)  
round\_lev,  
(NEG\_U round\_lev)[2:input\_exp+2], #NEG sign extends#  
round\_sel),

out\_sel = CASE difference  
OF diff: left  
ELSE right  
ESAC,

OUTPUT (MUX\_2(STRING[input\_exp]bit))

```

    pro_no[3..input_exp+2],
    pro_new[2..input_exp+1],
    out_sel),
    lev[2..input_exp+1],
    sgn_level)

```

END.

#actel 1 bit full adder with active low cin and cout#  
 FN FA1B = (bit: ah bin cinb) -> (bit: bit):#cob,s#  
 BEGIN

```

    LET  a_c = B_TO_S ah CONC NOT_B(B_TO_S cinb),
          b_c = B_TO_S bin CONC NOT_B(B_TO_S cinb),
          out = ADD_U(a_c,b_c).
    OUTPUT(CAST(bit) NOT_B(B_TO_S out(1)), out(2))
  END.

```

#a Ripple carry adder using 1 bit full adder blocks#

#the actel version of the ADD BIOP's#

```

MAC ADD_S_ACTEL = (STRING(INT m)bit:ah,STRING(INT n)bit:bin,bit:cinb) -> STRING(m)
BEGIN
  MAKE (IF m>n THEN m ELSE n)FI FA1Bsum.

```

#signed nos so sign extend #

```

    LET a_c = IF m>n THEN ah ELSE ALL_SAME(n-m)B_TO_S ah(1) CONC ah FI,
          b_c = IF n>m THEN bin ELSE ALL_SAME(m-n)B_TO_S bin(1) CONC bin FI.
    LET subsigned = sum.
  #isb#

```

```

JOIN  (a_c||f m>=n THEN m ELSE n F1).b_c||f m>=n THEN m ELSE n F1).c||b) ->sum||f m>=n THEN m ELSE n F1).

FOR INT j=1.(||f m>=n THEN m ELSE n F1) - 1
JOIN (a_c||f m>=n THEN m ELSE n F1) -j).b_c||f m>=n THEN m ELSE n F1) -j).
sum||f m>=n THEN m ELSE n F1) -j+1||1)) ->sum||f m>=n THEN m ELSE n F1) -j).

OUTPUT CAST(STRING||f m>=n THEN m+1 ELSE n+1 F1).b1)
(NOT_B1B_TO_5 sum||f1)) CONC
CAST(STRING||f m>=n THEN m ELSE n F1).b1)(INT j=1..||f m>=n THEN m ELSE n F1) sum||j(2))
END.

MAC ADD_US_ACTEL = (STRING(INT m).b1:c||a||n,STRING(INT n).b1:c||b||n) ->STRING||f m>=n THEN m+1 ELSE n+1 F1).b1:
BEGIN
MAKE ||f m>=n THEN m ELSE n F1).A1B:sum.

#unsigned nos so extend by 0#
LET a_c = ||f m>=n THEN a||n ELSE ZERO(n-m).b'0' CONC a||n F1.
b_c = ||f n>=m THEN b||n ELSE ZERO(m-n).b'0' CONC b||n F1.
LET subsignal = sum.

#1sb#
JOIN (a_c||f m>=n THEN m ELSE n F1).b_c||f m>=n THEN m ELSE n F1).c||b) ->sum||f m>=n THEN m ELSE n F1).

FOR INT j=1.(||f m>=n THEN m ELSE n F1) - 1
JOIN (a_c||f m>=n THEN m ELSE n F1) -j).b_c||f m>=n THEN m ELSE n F1) -j).
sum||f m>=n THEN m ELSE n F1) -j+1||1)) ->sum||f m>=n THEN m ELSE n F1) -j).

OUTPUT CAST(STRING||f m>=n THEN m+1 ELSE n+1 F1).b1)
(NOT_B1B_TO_5 sum||f1)) CONC
CAST(STRING||f m>=n THEN m ELSE n F1).b1)(INT j=1..||f m>=n THEN m ELSE n F1) sum||j(2))

```

END.

MAC ADD SUB ST = (STRING(INT m)bit:ain, STRING(INT n)bit:bn, l\_add:sel) -> STRING(IF m=n THEN m+1 ELSE n+1 FI)bit:

BEGIN

# sign extend inputs #

LET a\_s = CAST(STRING(1)bit:aln(1) CONC aln,

b\_s = CAST(STRING(1)bit:bn(1) CONC bn,

sel\_bit = CAST(STRING(1)bit:sel,

# ACTEL #

bn\_inv = XOR\_B(n+1)(b\_s, ALL\_SAME(n+1)sel\_bit).

# chnb is active low so cast sel(add->0, sub->1) & invert it #

out = ADD\_S ACTEL(a\_s, bn\_inv, CAST(bn)NOT\_B sel\_bit).

bnout = out[2..IF m>n THEN m+2 ELSE n+2 FI]

OUTPUT bnout

END.

# transformation ops #

MAC B\_TO\_S = (bit:in) -> STRING(1)bit: CASE in

OF b'0:b'0',

b'1:b'1'

ESAC.

MAC I\_TO\_SC(INT n) = (l\_result:in) -> (flag, STRING(n)bit): BIOP TRANSFORM S.

MAC SC\_TO\_I(INT n) = (STRING(n)bit:in) -> (flag, l\_result): BIOP TRANSFORM S.

MAC S\_TO\_IN = (STRING(INT n)bit:in) -> (flag, l\_input): BIOP TRANSFORM S.

MAC IN\_TO\_S(INT n) = (l\_input:in) -> (flag, STRING(n)bit): BIOP TRANSFORM S.

```

MAC_U_TO_IN = (STRING(INT n)(bit:in) -> (flag, l_input): BIOP TRANSFORM_US.

MAC_U_TO_LEN = (STRING(INT n)(bit:in) -> (flag, l_length): BIOP TRANSFORM_US.
MAC_LEN_TO_U(INT n) = (l_length:in) -> (flag, STRING(n)(bit): BIOP TRANSFORM_US.

MAC_Q_TO_U(INT n) = (l_quant:in) -> (flag, STRING(n)(bit): BIOP TRANSFORM_US.
MAC_S_TO_C = (STRING(INT n)(bit:in) -> (flag, l_col): BIOP TRANSFORM_US.
MAC_S_TO_R = (STRING(INT n)(bit:in) -> (flag, l_row): BIOP TRANSFORM_US.
MAC_S_TO_B = (STRING(INT n)(bit:in) -> (flag, l_blk): BIOP TRANSFORM_US.
MAC_S_TO_SUB = (STRING(INT n)(bit:in) -> (flag, l_sub): BIOP TRANSFORM_US.
MAC_S_TO_SPARC = (STRING(INT n)(bit:in) -> (flag, l_sparc_add): BIOP TRANSFORM_US.

MAC_C_TO_S(INT n) = (l_col:in) -> (flag, STRING(n)(bit): BIOP TRANSFORM_US.
MAC_R_TO_S(INT n) = (l_row:in) -> (flag, STRING(n)(bit): BIOP TRANSFORM_US.

MAC_I_TO_Q = (l_input:in) -> (l_quant:ARITH in.

```

```

MAC_B_TO_I = (bit:in) -> (result: CASE in
    OF b'0: result/0,
       b'1: result/1
    ESAC.

MAC_CARRY = (l_add:in) -> STRING(1)(bit: CASE in
    OF add:b'0',
       sub:b'1'
    ESAC.

MAC_BOOL_BIT = (bool:in) -> STRING(1)(bit:
    CASE in
    OF t:b'1'

```

ELSE b'0'  
ESAC.

MAC BOOL STRING(INT n) = (inpad:n) -> STRING[n] bit:  
(LET out = BOOL\_BIT in[1].  
OUTPUT IF n=1

THEN out  
ELSE out[1] CONC BOOL\_STRING(n-1)(in[2..n])  
FI

).

MAC BIT\_STRING(INT n) = (inpad:n) -> STRING[n] bit:  
(LET out = B\_TO\_S in[1].  
OUTPUT IF n=1

THEN out  
ELSE out[1] CONC BIT\_STRING(n-1)(in[2..n])  
FI

).

MAC ZERO(INT n) = (STRING[1]bit:dummy) -> STRING[n]bit:  
IF n=1 THEN b'0'  
ELSE b'0' CONC ZERO(n-1) b'0'  
FI.

MAC ALL\_SAME(INT n) = (STRING[1]bit:dummy) -> STRING[n]bit:  
IF n=1 THEN dummy  
ELSE dummy CONC ALL\_SAME(n-1) dummy  
FI.

**COM**

The operators described in this section are optimal and take two-valued operands and produce a two-valued result. They may not be used with ELLA-integers or associated types.

The first basic value of any two-valued type declaration of the operand(s) and the result are interpreted by the operations as false, and the second basic value is interpreted as true. Thus, given the following type declarations:

**MOC**

**MAC AND\_T = (TYPE t a b) -> t: BIOP AND.**

**MAC OR\_T = (TYPE t: a b) -> t: BIOP OR.**

**MAC XOR\_T = (TYPE t: a b) -> t: BIOP XOR.**

**MAC NOT\_T = (TYPE t: a) -> t: BIOP NOT.**

**COM**

The following operations take bit-string operand(s) and are bitwise, ie the operation is performed on the operand(s) one bit at a time. The operand(s) and result must all be ELLA-strings of the same length.

**MOC**

**MAC AND\_B = (STRINGINT nbit, STRING(nbit)) -> STRING(nbit): BIOP AND.**

**MAC OR\_B = (STRINGINT nbit, STRING(nbit)) -> STRING(nbit): BIOP OR.**



MAC XOR\_B = (STRINGINT nbit, STRING(nbit) -> STRING(nbit):  
BIOP XOR.

MAC NOT\_B = (STRINGINT nbit) -> STRING(nbit):  
BIOP NOT.

# COM

The operators described in this section may be used with primitive types be  
all enumerated types, except associated types, rows, strings and structures.  
These operations take two operands which must be of the same type and the  
result can be any two-valued type; we have packaged these BIOPs so they output  
a value of type 'bool' - you may change this if you wish.

## MOC

MAC EQ = (TYPE t: a b) -> bool: BIOP EQ.

MAC GT = (TYPE t: a b) -> bool: BIOP GT.

MAC GE = (TYPE t: a b) -> bool: BIOP GE.

MAC LT = (TYPE t: a b) -> bool: BIOP LT.

MAC LE = (TYPE t: a b) -> bool: BIOP LE.

## COM

NOTE: these BIOPs are designed to take any primitive ELLA type. Since it is  
not possible to distinguish between primitive and other types, whilst leaving  
the macro declaration general enough to allow the use of all two-valued types  
that might be declared, there are type-checking limitations. This is done  
at network assembly, so use of illegal types will not generate an error

message until then.

NB: ARITH provides for relational operations on ELLA integer types.  
MOC

COM

These operations are optimized in their handling of '?' and operate on bit-string representations of unsigned integers. The result may be any two-valued type; we have used type 'bool'. The inputs can be of different lengths and different types.

MOC

MAC EQ\_U = (STRINGQINT n1b1,STRINGQINT m1b1) -> bool:  
BIOP EQ\_US.

MAC GT\_U = (STRINGQINT n1b1,STRINGQINT m1b1) -> bool:  
BIOP GT\_US.

MAC GE\_U = (STRINGQINT n1b1,STRINGQINT m1b1) -> bool:  
BIOP GE\_US.

MAC LT\_U = (STRINGQINT n1b1,STRINGQINT m1b1) -> bool:  
BIOP LT\_US.

MAC LE\_U = (STRINGQINT n1b1,STRINGQINT m1b1) -> bool:  
BIOP LE\_US.

# Bit-strings representing signed numbers #  
COM

These operations are optimal and operate on bit-string representations of signed integers. The result may be any two-valued type; we have used type

'bool'. The inputs can be of different lengths and different types.  
MOC

MAC EQ\_S = (STRING(INT n)bit,STRING(INT m)bit) -> bool:  
BIOP EQ\_S.

MAC GT\_S = (STRING(INT n)bit,STRING(INT m)bit) -> bool:  
BIOP GT\_S.

MAC GE\_S = (STRING(INT n)bit,STRING(INT m)bit) -> bool:  
BIOP GE\_S.

MAC LT\_S = (STRING(INT n)bit,STRING(INT m)bit) -> bool:  
BIOP LT\_S.

MAC LE\_S = (STRING(INT n)bit,STRING(INT m)bit) -> bool:  
BIOP LE\_S.

#### # Shift operations # COM

These operate on bit-strings. Both the enclosing macro and the BIOP are parameterised by the number of bits to be shifted (INT p). The macro and BIOP parameters must match. Note that no bits are lost in these shift operations, so you may need to trim the result to achieve the desired effect.

SR means shift right; SL means shift left.

The macros with the suffix '\_S' perform arithmetic shifts; those with the

suffix '\_' perform bool shifts.  
MOC

MAC SL\_S(INT p) = (STRINGINT n)bit -> STRINGIn + p)bit:  
BIOP SL(p).

MAC SL\_U(INT p) = (STRINGINT n)bit -> STRINGIn + p)bit:  
BIOP SL(p).

MAC SR\_S(INT p) = (STRINGINT n)bit -> STRINGIn + p)bit:  
BIOP SR\_S(p).

MAC SR\_U(INT p) = (STRINGINT n)bit -> STRINGIn + p)bit:  
BIOP SR\_US(p).

# Arithmetic operations #

# Bit-strings representing unsigned numbers #

# addition. #

MAC ADD\_U = (STRINGINT m)bit, (STRINGINT n)bit  
-> STRINGIF m >= n THEN m+1 ELSE n+1 F)bit:  
BIOP PLUS\_US.

# subtraction on bit-string representations of unsigned integers. Output is #  
# signed. #

MAC SUB\_U = (STRINGINT m)bit, (STRINGINT n)bit  
-> STRINGIF m >= n THEN m+1 ELSE n+1 F)bit:

BIOP MINUS\_US.

# negation. Output is signed. #

MAC NEG\_U = (STRINGINT m)bit -> STRING(n+1)bit;

BIOP NEGATE\_US.

# multiplication. #

MAC MULT\_U = (STRINGINT m)bit, (STRINGINT n)bit -> STRING(m+n)bit;  
BIOP TIMES\_US.

COM

- divide. If the divisor is non-zero then the first element of the output is 'ok' and the second and third elements are the quotient and remainder; otherwise, the first element is 'error' and the rest is set to '7'.

MOC

MAC DIV\_U = (STRINGINT m)bit, (STRINGINT n)bit  
-> (flag, STRING(m)bit, STRING(n)bit);

BIOP DIVIDE\_US.

# square root. #

MAC SORT\_U = (STRINGINT n)bit -> STRING((n+1) % 2)bit;  
BIOP SORT\_US.

COM

modulus (result always positive). If the divisor is non-zero, then the first element of the output is 'ok' and the second element is the modulus; otherwise, the first element is 'error' and the second is '7'.

MOC

```
MAC MOD_U = (STRING(INT m)bit,STRING(INT n)bit)
-> (flag,STRING(n)bit);
BIOP MOD_US.
```

COM

- convert between one range of bit-string and another. If the input value cannot be represented as a legal value for the output string, the result is 'error' and '?'.  
MOC

```
MAC RANGE_U (INT m) = (STRING(INT n)bit)
-> (flag,STRING(m)bit);
BIOP RANGE_US.
```

# Bit-strings representing signed numbers #

# addition. #

```
MAC ADD_S = (STRING(INT m)bit,STRING(INT n)bit)
-> STRINGIF m >= n THEN m+1 ELSE n+1 F)bit;
BIOP PLUS_S.
```

# subtraction. #

```
MAC SUB_S = (STRING(INT m)bit,STRING(INT n)bit)
-> STRINGIF m >= n THEN m+1 ELSE n+1 F)bit;
BIOP MINUS_S.
```

# negation. #

MAC NEG\_S = (STRINGINT n)bi -> STRING(n+1)bi:  
BIOP NEGATE\_S.

# multiplication. #

MAC MULT\_S = (STRINGINT m)bi, (STRINGINT n)bi -> STRING(m+n)bi:  
BIOP TIMES\_S.

COM

divide. If the divisor is non-zero then the first element of the output is 'ok' and the second and third elements are the quotient and remainder, otherwise, the first element is 'error' and the rest is set to '?'. The remainder has the same sign as the divisor.

MOC

MAC DIV\_S = (STRINGINT m)bi, (STRINGINT n)bi  
-> ((tag, STRING(m)bi, STRING(n)bi):  
BIOP DIVIDE\_S.

COM

modulus (result always positive). If the divisor is non-zero, then the first element of the output is 'ok' and the second element is the unsigned modulus; otherwise, the first element is 'error' and the second is '?'.  
MOC

MAC MOD\_S = (STRINGINT m)bi, (STRINGINT n)bi  
-> ((tag, STRING(m)bi):  
BIOP MOD\_S.

COM

- convert between one range of bit-string and another. If the input value cannot be represented as a legal value for the output string, the result is 'error' and '?'.  
MOC

MAC RANGE\_S (INT m) = (STRING(INT n)bit)  
-> (flag, STRING(n)bit):  
BIOP RANGE\_S.

# absolute value. The output represents an unsigned integer. #

MAC ABS\_S = (STRING(INT n)bit) -> STRING(n)bit:  
BIOP ABS\_S.

# Built in Register #

MAC DREG(INT interval delay) = (TYPE i) -> t:  
ALIEN REGISTER (interval, n, 0, delay).

MAC GEN\_DREG(INT interval, CONST (TYPE i): int, INT skew delay) = (t) -> t:  
ALIEN REGISTER (interval, int, skew, delay).

# Built in type conversion #

MAC CAST(TYPE i) = (TYPE s) -> t:  
ALIEN CAST.



```

MAC ALL_SAME(INT n) = (STRING(1)bit:dummy) -> STRING(n)bit:
BEGIN
  FAULT IF n < 1 THEN 'N<1 in ALL_SAME' FI.
  OUTPUT IF n=1 THEN dummy
  ELSE dummy CONC ALL_SAME(n-1) dummy
FI
END.

```

```

MAC CAST (TYPE to) = (TYPE from:h) ->to:ALIEN CAST.

```

```

MAC ZERO(INT n) = (STRING(1)bit:dummy) ->STRING(n)bit:
BEGIN
  FAULT IF n < 1 THEN 'N<1 in ZERO' FI.
  OUTPUT IF n=1 THEN b'0'
  ELSE b'0' CONC ZERO(n-1) b'0'
FI
END.

```

```

MAC B_TO_S= (bit:h) ->STRING(1)bit: CASE h
  OF b'0:b'0',
     b'1:b'1'
  ESAC.

```

```

MAC S_TO_IN = (STRING(input_exp)bit:h) -> (flag,1,input): BIOP TRANSFORM S.
MAC IN_TO_S(INT n) = (1,input:h) -> (flag,STRING(n)bit): BIOP TRANSFORM S.

```

```

MAC S_HUFF = (STRING(6)bit) -> (flag,1,huffman): BIOP TRANSFORM US.
MAC HUFF_S = (1,huffman) -> (flag,STRING(6)bit): BIOP TRANSFORM US.

```

```

MAC BOOL_BIT = (bool:h) ->STRING(1)bit:

```

```

CASE h
  OF 1:b'1'
  ELSE b'0'
  ESAC.
MAC BIT_BOOL = (b1:n)    ->bool:
CASE h
  OF b'1':
  ELSE 1
  ESAC.

```

```

MAC BOOL_STRING(INT n) = ([n]bool:n) ->STRING[n] bit:
(LET out = BOOL_BIT h[1].
 OUTPUT IF n=1

```

```

  THEN out
  ELSE out[1] CONC BOOL_STRING(n-1)([n2..n])
FI

```

```

).
# defines the types used for the 2D wavelet chip#

```

```

#constant values#
INT result_exp=14,    #length of result arith#
input_exp=10,    #length of 1D convolver input/output#
qmax = 7,    #maximum shift value for quantisation constant#
result_range = 1 SL (result_exp-1),
input_range = 1 SL (input_exp-1),
max_octave=3, #no of octaves=max_octave +1, can not be less in this example#
no_octave=max_octave+1, #*#
ysize = 10, #no of bits for ximage#
ysize = 9, #no of bits for yimage#
ximage=319, #the xdimension -1 of the image, ie no of cols#

```

yimage=239 #the ydimension -1 of the image, ie no of rows#

#int types#

TYPE l\_result= NEW result/( -(result\_range)..(result\_range-1)).

l\_input= NEW input/( -(input\_range)..(input\_range-1)).

l\_length= NEW len/(0..15).

l\_hrp = NEW hrp/(0..1023).

l\_btk = NEW btk/(0..3).

l\_sub =NEW sub/(0..3).

l\_col =NEW col/(0..ximage).

l\_row =NEW row/(0..yimage).

l\_carry =NEW carry/(0..1).

l\_quant =NEW quant/(0..qmax).

#address for resultbdw memory, ie 1 frame#

l\_sparc\_addr =NEW addr/(0..(1 Sl\_max\_octave)\*(ximage+1)\*(yimage+1)+(ximage+1))-1 ).

l\_octave=NEW ocd/(0..(max\_octave+1)).

#bit string and boolean types#

bit = NEW b(0 | '1).

bood = NEW (f|f).

llag = NEW(error | ok).

#control signals#

l\_reset = NEW(rs|no\_rs).

l\_load = NEW(write|read). #r/wbar control#

l\_cs = NEW(no\_select|select). #chip select control#

l\_updown= NEW(down|up). #up/down counter control#

l\_diff= NEW(diff|nodiff). #diff or not in quantiser#

l\_hvra = NEW(integral|iter).

```

#convolver mux & and types#
    i_mux = NEW(ceil(right)).
    i_mux3 = NEW(1|c|f).
    i_mux4 = NEW(uno|dos|tres|quatro).
    i_add = NEW(add|sub).
    i_direction = NEW(forward|inverse).

#counter types#
    i_count_control = NEW(count_rst|count_carry).
    i_count_2 = NEW(one|two).

#state types#
    i_token = NEW(0|1|_1|_1|_1|_100|_101).
    i_mode = NEW(vold|vold_still|stop|send|still|still_send|pf_send|pf_still|pf_stop).
    i_cycle = NEW(token_cycle|data_cycle|skip_cycle).
    i_state = NEW(start|up|up_1|zz0|zz_1|zz2|zz3|down1).
    i_decode = NEW(load_low|load_high).
    i_high_low = NEW(low|high).
    i_huffman = NEW(pass|huffman).
    i_fifo = NEW(ok_fifo|error_fifo).

#types for the octave control unit#
    i_channel = NEW(y|u|v).
    i_channel_factor = NEW(hum|hance|color).
#types for the control of memory ports#
    i_sparcport = (i_sparc_add|rwr_addr#j_sparc_add|rdr_addr#j_load|fwr#j_cal|cal)

#generate random values for test memories#

FN GEN_RANDOM_MEM = (boot:ok,i_reset:reset) -> i_input BOOL_INT10 PRBS11(dx,reset).
TYPE i_test = NEW(no|yes).
#.....#
#These functions change types from boolean to integer and vice-#

```

#versa. Supports 1 & 8 bit booleans.  
#.....#

FN INT\_BOOL1=(I\_input:k) ->bool: # 1bit input to binary #

CASE k  
OF input/0:1,  
input/1:1

ESAC.

FN BOOL\_INT=(bool:b) ->I\_input: # 1 bit bool to input #

CASE b  
OF I\_input/0,  
I\_input/1

ESAC.

FN \* =(I\_input:a b) ->I\_input: ARITH a\*b.

FN % =(I\_input:a b) ->I\_input: ARITH a%b.

FN - =(I\_input:a b) ->I\_input: ARITH a-b.

FN + =(I\_input:a b) ->I\_input: ARITH a+b.

FN = =(I\_input:a b) ->I\_test: ARITH IF a=b THEN 2 ELSE 1 FI.

COM

FN CHANGE\_SIGN = (I\_input:i) ->I\_input: #changes sign for 8-bit 2's#

ARITH IF I<0 THEN 128+I #complement no, #

ELSE 1

FI.

FN SIGN = (I\_input:i) ->bool: #gets sign for 2's#

ARITH IF I<0 THEN 1 #complement nos #

ELSE 2

F1.

```

FN TEST_SIZE = (l_input:x) -> bool:
#test to see if the input is bigger than an 8-bit integer#
ARITH IF ( (x<=-128) AND (x>127)) THEN 1
ELSE 2 F1.

```

```

FN INT8_BOOL=(l_input:orig) ->[8]bool:
BEGIN

```

```

    SEQ

```

```

    VAR i1:=input/0, #input variables#
    i0:=CHANGE_SIGN(orig),
    b:=(i1,i1,i1,i1,SIGN(orig));
    [INT n=1..7] (
        i1:=i0%input/2;
        b[n]:=INT_BOOL1(i0-input/2^i1);
        i0:=i1
    );

```

```

    OUTPUT CASE TEST_SIZE orig #checks to see if orig will#
    OF: [8]bool, #fit input to an 8 bit value#
        f, b
    ESAC

```

```

END.

```

```

FN BOOL_INT8=(p[8]bool:b) -> l_input: #converts 8bit boolean to 2's#
BEGIN
    SEQ #complement integer #
    VAR sum:=-input/-128 * BOOL_INT(b[p8]).
    exp:=-input/1;

```

```

[INT k=1..7]
( sum:=sum+exp*BOOL_INT(p[k]);
exp:=input/2 * exp
);
OUTPUT sum
END.

```

```

MOC
FN BOOL_INT10=(10|bool:b) ->1 input: #converts 10bit boolean to 2's#
BEGIN
  SEQ #complement integer #
  VAR sum:=input/512 * BOOL_INT(p[10]).
  exp:=input/1;
  [INT k=1..9]
  ( sum:=sum+exp*BOOL_INT(p[k]);
    exp:=input/2 * exp
  );
  OUTPUT sum
END.

```

```

COM
FN BOOL_INT16=(16|bool:in1 n2) ->1 input:
# converts a 16-bit no. (sbs,msbs) input to integer form#
(BOOL_INT8(n1))+(input/256)*BOOL_INT8(n2)+(input/256)*BOOL_INT(n1|n2)).
#hack because of sign extend#
#of lsb #

```

```

MOC
COM
FN PRBS10 = (1_reset:reset) ->{10|bool:
#A 10 bit prbs generator, feedback taps on regs 3 & 10.#
BEGIN

```

```
MAKE[10]MYLATCH1;  
XNOR:xor.
```

```
FOR INT k=1..9 JOIN  
  (reset,[k]) ->[k+1].
```

```
JOIN (reset,xor) ->[1].  
([10],[3]) ->xor.
```

```
OUTPUT 1
```

```
END.
```

```
MOC
```

```
FN PRBS11 = (bool:ck,reset:reset) ->[10]bool:
```

```
#A 11 bit prbs generator,feedback taps on regs 2 & 11.#
```

```
BEGIN
```

```
MAKE[11]DFF(bool)1.
```

```
XOR:xor.
```

```
FOR INT k=1..10 JOIN
```

```
  (ck,reset,[k],0) ->[k+1].
```

```
JOIN (ck,reset,NOT xor,0) ->[1].  
  ([11],[12]) ->xor.
```

```
OUTPUT q1..10
```

```
END.
```

```
COM
```

```
FN PRBS16 = (bool:reset)->[16]bool:
```

```
#A 16 bit prbs generator,feedback taps on regs 1,3,12,16#
```

```
BEGIN
```

```
MAKE[16]MYLATCH1;
```



```
XOR_4xor,
NOT xor.
```

```
FOR INT k=1..15 JOIN
  (ck,reset,[k])->[k+1].
```

```
JOIN (ck,reset,xnor) ->[1],
  ([1],[3],[16],[12]) ->xor,
  xor ->xnor.
```

```
OUTPUT ([INT k=1..16][k])
```

```
END.
```

```
FN PRBS12 = (clock:ck,boot:reset) ->[12]boot:
```

```
#A 12 bit prbs generator,feedback taps on regs 1,4,6,12.#
```

```
BEGIN
```

```
  MAKE[12]MYLATCH1,
```

```
  XOR_4xor,
```

```
  NOT xor.
```

```
  FOR INT k=1..11 JOIN
    (ck,reset,[k])->[k+1].
```

```
  JOIN (ck,reset,xnor) ->[1],
    ([1],[4],[6],[12]) ->xor,
```

```
  xor ->xnor.
```

```
  OUTPUT ([INT k=1..12][k])
```

```
END.
```

```
FN PRBS8 = (clock:ck,boot:reset) ->[8]boot:
```

```
#A 8 bit prbs generator,feedback taps on regs 2,3,4,8.#
```

```
BEGIN
```

```
  MAKE[8]MYLATCH1,
```

XOR\_4:xor,  
NOT:xnor.

FOR INT k=1..7 JOIN  
(ck,reset,[k])->[k+1].

JOIN (ck,reset,xnor) ->[1],  
([2],[3],[4],[8]) ->xor,  
xor ->xnor.  
OUTPUT ([INT k=1..8][k])  
END.

MOC

#test for palmas chip#

TYPE 1 \_m132 = NEW m132/(-2147483000..2147483000).

FN RMS = (boud:ck,1,reset:reset,1\_cycle:cycle,1\_input:old new) ->1 \_m132  
BEGIN

FN I\_32 = (1\_input:in) ->1 \_m132:ARITH in.  
FN DV = (1 \_m132:a b) ->1 \_m132:ARITH a%b.  
FN PL = (1 \_m132:a b) ->1 \_m132:ARITH a+b.  
FN MI = (1 \_m132:a b) ->1 \_m132:ARITH a-b.  
FN TI = (1 \_m132:a b) ->1 \_m132:ARITH a\*b.

MAKEDFF \_INIT(1 \_m132):old \_error.

LET err = 1 \_32old MI 1 \_32new,  
err2 = (err1|err) PL old \_error.

JOIN (ck,reset,CASE cycle  
Ofdata\_cycle:write

```

ELSE read
  ESAC,err2,int32/0) -->old_error.

OUTPUT old_error
END.

FNEQ = (!_inp:a b) ->bod:ARITH IF a=b THEN 2
      ELSE 1
      FI.

FN SPARC_MEM = (!_input:n,l_sparc_addr:rw_addr,l_sparc_addr:rd_addr,l_load:rw_sparc,l_cs:cs) ->1_input:
RAM(input/0).

FN FIFO = (bod:ck,l_reset:reset,STRING(16)bit:buffer_in,l_direction:direction,l_load:fifo_read fifo_write)
BEGIN
  FN FIFO_RAM = (STRING(16)bit:n,l_inp:rw_addr rd_addr,l_load:rw_fifo) ->STRING(16)bit:
RAM(b'00000000000000000000000000000000).

  FNFULL = (!_inp:n) ->1_fifo:ARITH IF in>1023 THEN 2 #fifo full#
          ELSE 1
          FI.

  FNINGCR = (!_inp:n) ->1_inp:ARITH ln+1.

  FNEEMPTY = (!_inp:n) ->1_fifo:ARITH IF ln<0 THEN 2 #fifo empty#
            ELSE 1
            FI.

  FNDECR = (!_inp:n) ->1_inp:ARITH ln-1.

MAKEDFF(!_inp):address,

```

FIFO\_RAM:ram.

```

LET next = CASE direction
OF forward: CASE fifo_write
OF write: INCR address
ELSE address
ESAC,
inverse: CASE fifo_read
OF read: INCR address
ELSE address
ESAC
ESAC.

```

```

JOIN (ck_reset,next,inp0) -> address,
(buffer_in_address,address,CASE direction
OF inverse: read,
forward: fifo_write
ESAC) -> ram.

```

```

OUTPUT (ram,(FULL address,EMPTY address))
END.

```

```

FN TEST PALMAS = (bool:ck,l_reset:reset,l_direction:direction,l_intra_intra_inter,l_channel_factor:channel_factor,
l_input:q_in,l_quant:quant_norm,l_result:threshold comparison)
-> (STRING[16]bit,#buffer_out#[2]l_load:fifo_read fifo_write,bool,bool,l_int32):

```

BEGIN

```
MAKE SPARC_MEM:new old_inw old_forw,
FIFO:ffo,
PALMAS:palmas_inw palmas_forw.

LET   col_length = (IN_TO_S(9) input/31)[2].

row_length = (IN_TO_S(9) input/31)[2].

ximage_string = (IN_TO_S(9) input/32)[2].

yimage_string = (IN_TO_S(9) input/32)[2].

yimage_string_3 = (IN_TO_S(9) input/80)[2].

pro_forw = palmas_forw[1].

pro_inw = palmas_inw[1].

forw_frame_done = palmas_forw[7].

inw_frame_done = palmas_inw[7].

cycle = palmas_inw[8].

old_equal = CASE cycle
OF data_cycle:old_forw EQ palmas_inw[1]
ELSE 1
ESAC.
```

JOIN

```
#fix fifo full/empty logic later#
(ck,reset,forward,intra_inler,channel_factor,q_int,quant_norm,b'0000000000000000',new,old_forw,threshold,comparison,
#fifo[2][1],fifo[2][2]#ok_fifo,ok_fifo,col_length,row_length,ximage_string,yimage_string_3)
->palmas_forw,

(ck,reset,inverse,intra_inler,channel_factor,q_int,quant_norm,fifo[1],new,old_inv,threshold,comparison,
#fifo[2][1],fifo[2][2]#ok_fifo,ok_fifo,col_length,row_length,ximage_string,yimage_string_3)
->palmas_inv,

#old forward mem, on forward use as normal, on inverse read values to compare with inverse#
(pro_forw,CASE direction
  OF forward:palmas_forw[2],
    inverse:palmas_inv[2]
  ESAC, CASE direction
    OF forward:palmas_forw[2],
      inverse:palmas_inv[2]
    ESAC, CASE direction
      OF forward:palmas_forw[4][1],
        inverse:read
      ESAC) ->old_forw,

(palmas_inv[1],palmas_inv[2],palmas_inv[2],CASE direction
  OF forward:read,
    inverse:palmas_inv[4][1]
  ESAC) ->old_inv,

#(input/0,palmas_forw[2],palmas_forw[2],palmas_forw[3][1]) ->new,#
(input/0,CASE direction
  OF forward:palmas_forw[2],
    inverse:palmas_inv[2]
  ESAC, CASE direction
```

```

OF forward:palmas_forw[2],
  inverse:palmas_inv[2]
ESAC,CASE direction
  OF forward:palmas_forw[3][1],
    inverse:read
  ESAC)
    ->new,

```

```

(ck,reset,CASE direction
  OF inverse:b"0000000000000000",
    forward:palmas_forw[5]
  ESAC
    ,direction, palmas_inv[6][1],palmas_forw[6][2]
  ->fifo.

```

```

OUTPUT (palmas_forw[5],palmas_forw[6],palmas_forw[7],old_equal,RMS(ck,reset,cycle,old_inv,new) )
END.

```

```

#test for palmas chip#
TYPE1_int32 = NEW int32/(-2147483000..2147483000).

```

```

FNRMS = (b00:ck,1_reset:reset,1_cycle:cycle,1_input:old new)->1_int32
BEGIN

```

```

FNI_32 = (1_input:in) ->1_int32:ARITH a.
FNDV = (1_int32:a b) ->1_int32:ARITH a%b.
FNP_L = (1_int32:a b) ->1_int32:ARITH a+b.
FNM1 = (1_int32:a b) ->1_int32:ARITH a-b.
FNTT = (1_int32:a b) ->1_int32:ARITH a*b.

```

```

MAKE OFF_INIT(1_int32):old_error.
LET err = 1_32old_M1_32new,
err2 = (err1|err) PL old_error.

```

```

JOIN (ck.reset,CASE cycle
      OF  data_cycle:write
      ELSE read
      ESAC,er2,ln320)      ->old_error.

OUTPUT old_error
END.

FNEQ = (!_input:a b) ->bool:ARITH IF a=b THEN 2
      ELSE 1
      FI.

FN SPARC_MEM = (!_input:in,!_sparc_addr:wr_addr,!_sparc_addr:rd_addr,!_load:rw_sparc,!_cs:cs#)->!_input:
RAM(!_input/0).

FN FIFO_BIG      =(bool:ck,!_reset:reset,STRING[16]bit:buffer_in,!_direction:direction,!_load:fifo_read,fifo_write)
->(STRING[16]bit,[2]!_fifo): #fifo_full,empty#
BEGIN

FN FIFO_RAM = (STRING[16]bit:in,!_sparc_addr:wr_addr,rd_addr,!_load:rw_fifo) ->STRING[16]bit:
RAM(b'00000000000000000000000000000000').

FN FULL = (!_sparc_addr:in) ->!_fifo:ARITH IF ln>1023 THEN 2      #fifo_full#
      ELSE 1
      FI.

FN INCR = (!_sparc_addr:ln) ->!_sparc_addr:ARITH ln+1.

FN EMPTY = (!_sparc_addr:in) ->!_fifo:ARITH IF ln<0 THEN 2 #fifo_empty#
      ELSE 1
      FI.

FN DECR = (!_sparc_addr:ln) ->!_sparc_addr:ARITH ln-1.

```



```

MAKE OFF( spare_addr):address,
FIFO_RAM:ram.
LET next = CASE direction
  OF forward: CASE fifo write
    OF write:INCR address
    ELSE address
    ESAC,
  Inverse: CASE fifo read
    OF read: INCR address
    ELSE address
    ESAC
ESAC.

```

```

JOIN (ck,reset,next_addr/0) ->address,
(buffer_in,address,address,CASE direction
  OF inverse:read,
  forward:fifo write
  ESAC) ->ram.

```

```

OUTPUT (ram,(FULL address,EMPTY address))
END.

```

```

FN TEST_PALMAS = (boot:ck,reset,bootload_memory,1_direction:direction,1_intratitra_inter,
  1_channel_factor:channel_factor,(4) quant:quant_norm,(4) result:threshold,
  1_input:col_length_in row_length_in ximage_string_in yimage_string_in,
  1_result:yimage_string_3_in)
->(boot/1_int32#):

```

BEGIN

FN NEW\_ADDRESS = (l\_sparc\_addr:ln) -> l\_sparc\_addr: ARITH ((ln + 1) MOD 120000).

MAKE SPARC\_MEM:new old\_inv old\_forw,  
FIFO\_BIG:ffio,  
PRBS11:prbs,  
DFF(l\_sparc\_addr):address,  
PALMAS:palmas.

LET col\_length = (IN\_TO\_S(10) col\_length\_ln)[2].

row\_length = (IN\_TO\_S(9) row\_length\_ln)[2].

ximage\_string = (IN\_TO\_S(10) ximage\_string\_ln)[2].

yimage\_string = (IN\_TO\_S(9) yimage\_string\_ln)[2].

yimage\_string\_3 = (I\_TO\_SC(11) yimage\_string\_3\_ln)[2].

pro = palmas[1].

random\_data = BOOL\_INT10 prbs.

frame\_done = palmas[7].

cycle = palmas[9].

old\_equal = CASE cycle



```

                                inverse:read
                                ESAC)
                                ->old_forw,

(CASE load_memory
  OF t:DFf(i_input)(ck,reset,random_data,input/0)
  ELSE palmas[1])
  ESAC , CASE load_memory
    OF t:address
      ELSE palmas[2]
      ESAC, palmas[2], CASE load_memory
        OF t:write
          ELSE CASE direction
            OF forward:read,
              inverse:palmas[4][1])
          ESAC
            ->old_inv,

(CASE load_memory
  OF t:random_data
  ELSE input/0)
  ESAC , CASE load_memory
    OF t:address
      ELSE palmas[2]
      ESAC, palmas[2], CASE load_memory
        OF t:write
          ELSE CASE direction
            OF forward:palmas[3][1],
              inverse:read
          ESAC
            ->new,

```

```

(ck,reset,CASE direction
  OF inverse:b"0000000000000000".
    forward:palmas[5]
  ESAC      .direction,palmas[6][1],palmas[6][2]    ->fifo.

OUTPUT (old_equal#,RMS(ck,reset,cycle,old_hrv,new)# )
END.

#test for palmas chip#
TYPE l_int32 = NEW int32/(-2147483000..2147483000).

FN RMS = (bodi:ck,l_reset:reset,l_cycle:cycle,l_input:old new) ->l_int32.
BEGIN
  FN l_32 = (l_input:in) ->l_int32:ARITH ln.
  FN DV = (l_int32:a b) ->l_int32:ARITH a%b.
  FN PL = (l_int32:a b) ->l_int32:ARITH a+b.
  FN MI = (l_int32:a b) ->l_int32:ARITH a-b.
  FN T = (l_int32:a b) ->l_int32:ARITH a*b.

  MAKEDEF _INIT(l_int32):old_error.

  LET err = l_32:old MI l_32:new,
    err2 = (errTlen) PL old_error.

  JOIN (ck,reset,CASE cycle
    OF data_cycle:write
      ELSE read
    ESAC,err2,int32/0) ->old_error.

```

OUTPUT odd\_error  
END.

FN EQ = (l\_inp:a b) -> bool:ARITH IF a=b THEN 2  
ELSE 1  
FI.

FN SPARC\_MEM = (l\_inp:in,l\_sparc\_addr:wr\_addr,l\_sparc\_addr:rd\_addr,l\_load:rw\_sparc/l\_cs:cs/l) -> l\_inp:  
RAM(inp:0).

FN FIFO = (bool:ok,l\_reset:reset,STRING(16)bt:buffer,l\_n,l\_direction:direction,l\_load:ffo\_read ffo\_write)  
-> (STRING(16)bt,l2n\_ffo): #ffo\_full,empty#

BEGIN

FN FIFO\_RAM = (STRING(16)bt:in,l\_inp:wr\_addr rd\_addr,l\_load:rw\_ffo) -> STRING(16)bt:  
RAM(b'00000000000000000000000000000000').

FN FULL = (l\_inp:in) -> l\_ffo:ARITH IF n>1023 THEN 2 #ffo\_full#  
ELSE 1  
FI.

FN INCR = (l\_inp:in) -> l\_inp:ARITH n+1.

FN EMPTY = (l\_inp:in) -> l\_ffo:ARITH IF n<0 THEN 2 #ffo\_empty#  
ELSE 1  
FI.

FN DECR = (l\_inp:in) -> l\_inp:ARITH n-1.

MAKEDFF(l\_inp):address,  
FIFO\_RAM:ram.

```
LET next = CASE direction
OF forward: CASE fifo_write
OF write: INCR address
ELSE address
ESAC,
inverse: CASE fifo_read
OF read: INCR address
ELSE address
ESAC
ESAC.
```

```
JOIN (ck,reset,next,inp0) -> address,
(buffer_in,address,address,CASE direction
OF inverse: read,
forward: fifo_write
ESAC) -> ram.
```

```
OUTPUT (ram,(FULL address,EMPTY address))
END.
```

```
FN TEST_PALMAS = (bool:ck,i_reset:reset,bool:load_memory,i_direction:direction,i_intra_intra_inter,i_channel_factor:channel_factor,
i_input:q_int,i_quant:quant_norm,i_result:threshold comparison)
-> (bool:i_hic32):
```

```
BEGIN
FN NEW_ADDRESS = (i_sparc_addr:in) -> i_sparc_addr: ARITH ((in+1) MOD 120000).
```

MAKE SPARC\_MEM:new old\_inv old\_forw,  
 FIFO:ffifo,  
 PRBS11:prbs,  
 DFF1\_sparc\_addr:address,  
 PALMAS:palmas.

```

LET   col_length = (IN_TO_S(10) input/31)[2].

      row_length = (IN_TO_S(9) input/31)[2].

      ximage_string = (IN_TO_S(10) input/32)[2].

      yimage_string = (IN_TO_S(9) input/32)[2].

      yimage_string_3 = (I_TO_SC(11) result/80)[2].

      pr0 = palmas[1].

      random_data = BOOL_INT10 prbs,

      frame_done = palmas[7].

      cycle = palmas[8].

      old_equal = CASE cycle
        OF data_cycle:old_forw EQ palmas[1]
        ELSE 1
        ESAC.
  
```



```

JOIN
#fix fifo/empty logic later#
(ck,reset,direction,inita_inter,channel_factor,q_inl,quant_norm,fifo[1],new,CASE direction
  OF forward:old_forw
    ELSE old_hv
      ESAC, threshold,comparison,
#fifo[2][1],fifo[2][2]#ck_fifo,ck_fifo,col_length,row_length,ximage_string,yimage_string,yimage_string_3)
->palmas,

(ck,reset,(NEW_ADDRESS address),addr/0)      -> address,

(ck,reset)      ->prbs,

#old forward mem, on forward use as normal, on inverse read values to compare with inverse#
(CASE load_memory
  OF: DFF(1_input)/(ck,reset,random_data,input/0)
  ELSE palmas[1]
  ESAC, CASE load_memory
    OF l:address
      ELSE palmas[2]
      ESAC, palmas[2], CASE load_memory
        OF l:write
          ELSE CASE direction
            OF forward:palmas[4][1],
              inverse:read
                ESAC
          ESAC)      ->old_forw,

(CASE load_memory
  OF l:DFF(1_input)/(ck,reset,random_data,input/0)
  ELSE palmas[1])

```

```
ESAC , CASE load_memory
  OF t:address
  ELSE palmas[2]
  ESAC, palmas[2], CASE load_memory
    OF t:write
    ELSE CASE direction
      OF forward:palmas[4][1],
        inverse:read
        ESAC
      ->old_inv,
      ESAC)

(CASE load_memory
  OF t:random_data
  ELSE Input)
  ESAC , CASE load_memory
    OF t:address
    ELSE palmas[2]
    ESAC, palmas[2], CASE load_memory
      OF t:write
      ELSE CASE direction
        OF forward:palmas[3][1],
          inverse:read
          ESAC
        ESAC)
      ->new,

(dx,reset,CASE direction
  OF inverse:b'0000000000000000',
  forward:palmas[5]
```

ESAC                    ,direction,palmas[6][1],palmas[6][2]                    ->fifo.  
OUTPUT (old\_equal,RMS(ck,reset,cycle,old\_inv,new) )  
END.

APPENDIX C

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Written by: Adrian Lewis

680X0 Fast Top Octave

seg 'klics'

macro

TOPX fDC, fHG, fOld, fXX

swap

fHG

move.w

fDC, fXX

neg.w

fDC

add.w

fHG, fDC

add.w

fXX, fHG

swap

fHG

move.l

fDC, fOld

: save DD

: HG=DC1

: HG=G1D

: DC=DD

: DC=D(-G0)

: XX=G0

: HG=G1H0

macro

TOPY

fHG0, fnew0, fHG1, fnew1, fXX

move.l

fnew0, fXX

move.l

fnew1, fHG1

add.l

fXX, fHG1

sub.l

fXX, fHG0

: new0=HG0

: new1=HG1

: copy HG

: read HG

: read HG

endm

macro

TOPELOCK

fDC0, fHG0, fnew0, fOld0, fDC1, fHG1, fnew1, fOld1, fXX

TOPY

fHG0, fnew0, fHG1, fnew1, fXX

TOPX

fDC0, fHG0, fOld0, fXX

TOPX

fDC1, fHG1, fOld1, fXX

endm

macro

TOPH

fDC, fHG, fnew, fOld, fXX

move.l

fnew, fHG

TOPX

fDC, fHG, fOld, fXX

endm

macro

TOPE

fDC, fOld, fXX

move.l

fDC, fXX

swap

fXX

move.w

fXX, fDC

move.l

fDC, fOld

: save DD

: DC=DD

: XX=GD

: XX=DC

| PC | PCBR | PCIC | EXPORT | ENDR | PCBR | PCIC | EXPORT | ENDR |
|----|------|------|--------|------|------|------|--------|------|
| 8  | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 9  | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 10 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 11 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 12 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 13 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 14 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 15 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 16 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
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| 20 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
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| 28 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
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| 30 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 31 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
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| 55 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 56 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 57 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 58 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 59 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 60 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 61 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 62 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 63 | 1    | 1    | 1      | 1    | 1    | 1    | 1      | 1    |
| 64 | 1    | 1    | 1      |      |      |      |        |      |

Engineering:KilicCode:CompAct:Top.e

a6

: remove locals  
: return

ENDFUNC

END

Engineering:KliscCode:CompPct:Table.a

-----  
 © Copyright 1993 KLICS Ltd.  
 All rights reserved.  
 -----  
 680XC Table Lookup RGB/YUV code  
 -----

machine MC68030  
 seg 'klisc'  
 if TYPE('seg')# 'UNDEFINED' then  
 seg 4seg  
 endit

\*\*\*\*\* EXPORT

PS RECORD 8  
 DS.L ?  
 ENDR

link a6, #0  
 movem.l d4-d7/a3-a5, -(a7)

move.l PS, Table(a6), a0

Table is (long) (20\*512) (long) (512-16)  
 : U value

shakeLoop  
 clr.l d0

move.w #512, d1

: 512

move.l d0, d2

move.w d2, d3

: U

: 20

add.w d2, d2

add.w d1, d2

: 20 + 512

1st.w #2, d2

move.w d2, (a0)+

: Place 1st word

add.w d3, d3

move.w d3, d2

: 20

add.w d3, d3

add.w d3, d3

: 60

sub.w d3, d3

1st.w #2, d1

: Place 1st word

add.w #1, d0

cmp.w #50200, d0

bne

move.l #50000200, d0

shakeLoop  
 clr.l d4

move.w #512, d1

: 512

move.w d0, d2

: U

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Engineering:K11csCde:CompPic:Table.a

Colors wanted are:

RED =  $(Y + 2V + 512) / 4$

GREEN =  $(Y - V + 512 - (60/16)) / 4$

BLUE =  $(Y + 2U + 512) / 4$

UTABLE part is for (2V + 512)

UTABLE part is for (512 - 160)

UTABLE part is for (2U + 512)

End : 00219013-1-00-1

```

move.w (a2)+,d2
and.w #503ff,d2
eobcixckd
:
1a6,d2.w+8),d3
d3,d6
4(a6,d2.w+8),d5
:green, dec ($12) / 4 for green
:blue, dec ($20 + $12) / 4 for blue = 1x +
:dup for second pair
:green, dec ($12) / 4 for green
:

```

[illegible]

```

: add r8 to r9 values - 127 to 127
move.l (a0)+,d0
:
x
-128 to -127
: y is
: red, get (y + 2v + 512) for red = (y +
: green, get (y + (512 - (60/16)) - v)
: blue, get (y + (2v + 512) for blue = 1

```

[illegible]

SUBSTITUTE SHEET (RULE 26)

```
:Pin at zero
:See if cover word went too positive
:Mask old data out
:New data is masked
```

[illegible]

00K  
9P'0P  
3IXI'0  
0P'9P  
5P'0P  
3IXI'0  
0P'5P  
9P'0P  
3IXI'0  
0P'9P  
EP'0P  
3IXI'0  
0P'EP  
2P'0P  
3IXI'0  
0P'2P  
TP'0P  
3IXI'0  
0P'TP

.....



[illegible]

Engineering:KljcsCode:CompFict:KljcsEnCode.h

.....  
 \* Copyright 1993 Kljcs Limited  
 \* All rights reserved.  
 \* Written by: Adrian Lewis  
 .....

```
typedef struct {
    int
    dtype; /* User - Bytes per frame in input stream */
    dtype; /* User - Bytes per frame in output stream */
    dtype; /* User - Buffer size (bytes) */
    Ecolean intra; /* Calc - Compression mode intra/inter */
    auto_q; /* User - Automatic quantization for rate control */
    buf_sw; /* User - Theoretical buffer on/off */
    quant; /* User - Starting quantizer value */
    thresh; /* User - Threshold factor */
    compare; /* User - Comparison factor */
    base[5]; /* User - Octave weighting factors */
    int
    buffer; /* Calc - Current buffer fullness (bytes) */
    prevbytes; /* Calc - Bytes sent last frame */
    prevquant; /* Calc - Quantization/activity for last frame */
    double tmp_quant; /* Calc - Current quantizer value quant */
} KljcsDataRec;

typedef struct {
    KljcsSeqHeader
    KljcsFrameHeader
    KljcsDataRec
    buffer
    KljcsRec; Kljcs;
    seq;
    end;
    buf;
}
```



580X0 K13cDecode code  
Fast code for:  
3/2 octave input stream  
2/1 octave output image

050892H      001425W

```

moveb.l %eax,%eax
subq.b $0x00000000,%eax
lsl.l $0,%eax
andl.v %eax,%eax
: spare AND=mark

```

[illegible]

[illegible]

[illegible]

but - 17c

```

:      lprtr, ldata, bno
:      move, l
:      sub, b
:      sub, bno, b
:      lstr, l
:      cltr, l
:      base, l
:      sub, bno, l
:      bbits, d1
:      bbits, d0
:      sign?
:      if positive goto pos
:      apply mask leaving level
:      level=level]
:      goto cont
:      and, l
:      d1, d0
:      lstr, l
:      move, w
:      add, result

```

MACRO  
INIX

(අභ්‍යං-අඳු) ධර්ම පරිපාලන : පරිපාලන මධ්‍යස්ථාන මධ්‍යස්ථාන

[illegible]

(20) 4.310  
VOID  
010000

Block data read/write:  
VOID, STILL, SEND, LPTSTILL

[illegible]

EXIP4, STILLSKER, SS-SKIP, SENSISKIF

.....

SKIP4 FUNC EXPORT

: 111 butter

bu:-inc  
a0,d6,d7  
SKIPPUFF  
a0,d6,d7,d0  
SKIPPUFF  
a0,d6,d7,d0  
SKIPPUFF  
a0,d6,d7,d0  
SKIPPUFF  
a0,d6,d7,d0  
SKIPPUFF

531

ENDLINE

STILLSKIP FLNC EXPORT

```

: BUF_INC
: BUF_GET
: 18 0 the STOP

```

but-117c 30.06.07  
but-9er 06.07  
beg-9 09x1  
bat SKIP4 06.07

१५६

b31

LP' 9P      305-742  
LP' 9P' 08      305-742

८५०

189

bu-210c  
bu-210g

5250

150

4195

ENDFUNC

SS-SKIP FUNC. EXPORT

```

: BUT_INC
: BUT_GET
: IF 0 THEN STOP

```

bu: 1-120  
bu: 1-120  
bu: 1-120  
bu: 1-120  
bu: 1-120

1458

၁၁၆-၂၈၇

Page 3  
b6  
b7C  
b7D  
b7E  
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b7VX  
b7VY  
b7VZ  
b7WA  
b7WB  
b7WC  
b7WD  
b7WE  
b7WF  
b7WG  
b7WH  
b7WI  
b7WJ  
b7WK  
b7WL  
b7WM  
b7WN  
b7WO  
b7WP  
b7WQ  
b7WR  
b7WS  
b7WT  
b7WU  
b7WV  
b7WW  
b7WX  
b7WY  
b7WZ  
b7XA  
b7XB  
b7XC  
b7XD  
b7XE  
b7XF  
b7XG  
b7XH  
b7XI  
b7XJ  
b7XK  
b7XL  
b7XM  
b7XN  
b7XO  
b7XP  
b7XQ  
b7XR  
b7XS  
b7XT  
b7XU  
b7XV  
b7XW  
b7XX  
b7XY  
b7XZ  
b7YA  
b7YB  
b7YC  
b7YD  
b7YE  
b7YF  
b7YG  
b7YH  
b7YI  
b7YJ  
b7YK  
b7YL  
b7YM  
b7YN  
b7YO  
b7YP  
b7YQ  
b7YR  
b7YS  
b7YT  
b7YU  
b7YV  
b7YW  
b7YX  
b7YY  
b7YZ  
b7ZA  
b7ZB  
b7ZC  
b7ZD  
b7ZE  
b7ZF  
b7ZG  
b7ZH  
b7ZI  
b7ZJ  
b7ZK  
b7ZL  
b7ZM  
b7ZN  
b7ZO  
b7ZP  
b7ZQ  
b7ZR  
b7ZS  
b7ZT  
b7ZU  
b7ZV  
b7ZW  
b7ZX  
b7ZY  
b7ZZ  
b7AA  
b7AB  
b7AC  
b7AD  
b7AE  
b7AF  
b7AG  
b7AH  
b7AI  
b7AJ  
b7AK  
b7AL  
b7AM  
b7AN  
b7AO  
b7AP  
b7AQ  
b7AR  
b7AS  
b7AT  
b7AU  
b7AV  
b7AW  
b7AX  
b7AY  
b7AZ  
b7BA  
b7BB  
b7BC  
b7BD  
b7BE  
b7BF  
b7BG  
b7BH  
b7BI  
b7BJ  
b7BK  
b7BL  
b7BM  
b7BN  
b7BO  
b7BP  
b7BQ  
b7BR  
b7BS  
b7BT  
b7BU  
b7BV  
b7BW  
b7BX  
b7BY  
b7BZ  
b7CA  
b7CB  
b7CC  
b7CD  
b7CE  
b7CF  
b7CG  
b7CH  
b7CI  
b7CJ  
b7CK  
b7CL  
b7CM  
b7CN  
b7CO  
b7CP  
b7CQ  
b7CR  
b7CS  
b7CT  
b7CU  
b7CV  
b7CW  
b7CX  
b7CY  
b7CZ  
b7DA  
b7DB  
b7DC  
b7DD  
b7DE  
b7DF  
b7DG  
b7DH  
b7DI  
b7DJ  
b7DK  
b7DL  
b7DM  
b7DN  
b7DO  
b7DP  
b

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SKIP

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```

: BUF_INX
: BUF_GET
: IF 0 THEN STOP
: BUF_GET

```

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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

    lne.s  =>  @nxt          : if 1 then VOID
    bsr    SKIP4
    @nxt    rts
    .
    ENDFUNC

SENDSKIP?  FUNC  EXPORT
    .
    buf_rinc  a0.d6.d7      : BUF_INC
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk1          : if 0 the STOP
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk0          : if 0 then STILLSEND
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk1          : if 0 then VOID
    @sk0      bsr           SKIP4
    buf_rinc  a0.d6.d7      : BUF_INC
    @sk1      buf_get       d6.d7         : BUF_GET
    beq.s     @sk3          : if 0 the STOP
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk2          : if 0 then STILLSEND
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk3          : if 0 then VOID
    @sk2      bsr           SKIP4
    buf_rinc  a0.d6.d7      : BUF_INC
    @sk3      buf_get       d6.d7         : BUF_GET
    beq.s     @sk5          : if 0 the STOP
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk4          : if 0 then STILLSEND
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk5          : if 0 then VOID
    @sk4      bsr           SKIP4
    buf_rinc  a0.d6.d7      : BUF_INC
    @sk5      buf_get       d6.d7         : BUF_GET
    beq.s     @nxt          : if 0 then STOP
    buf_get   d6.d7         : BUF_GET
    beq.s     @sk6          : if 0 then STILLSEND
    buf_get   d6.d7         : BUF_GET
    beq.s     @nxt          : if 0 then VOID
    @sk6      bsr           SKIP4
    @nxt      rts
    .
    ENDFUNC

```

```

.....
*
*   Octave Processing:
*
*   DCSTILLO, DOSEND0, DOSTILL1,
*   DOVOID1, DOSTILLSEND1, DOSEND1
*
.....

```

```

DOSTILLO  FUNC  EXPORT
.

```

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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

buf_rinc    a0,d6,d7      : BUF_INC
buf_get     d6,d7        : BUF_GET
bne.s       @still      : if 1 the STILL
rts

?still move.l    a1,a2          : caddr=baddr

        STILL      #4,d5,d3

        XVAL0      (a2),d3,a0,d6,d7,d0
        addq.l     #4,a2          : caddr+=x_blk
        XVAL0      (a2),d3,a0,d6,d7,d0
        adda.w     d5,a2          : caddr+=y_blk
        XVAL0      (a2),d3,a0,d6,d7,d0
        addq.l     #4,a2          : caddr+=x_blk
        XVAL0      (a2),d3,a0,d6,d7,d0

        bsr       STILLSKIP
        rts

        ENDFUNC

DOSEND0 FUNC      EXPORT

        buf_rinc    a0,d6,d7      : BUF_INC
        buf_get     d6,d7        : BUF_GET
        bne.s       @cont      : if 1 then continue
        rts

@cont move.l    a1,a2          : caddr=baddr
        buf_get     d6,d7        : BUF_GET
        beq.w       @ss        : if 0 then STILLSEND
        buf_get     d6,d7        : BUF_GET
        beq.w       @vd        : if 0 then VOID

        SEND      #4,d5,d3

        XDELTA      (a2),d3,a0,d6,d7,d0
        addq.l     #4,a2          : caddr+=x_blk
        XDELTA      (a2),d3,a0,d6,d7,d0
        adda.w     d5,a2          : caddr+=y_blk
        XDELTA      (a2),d3,a0,d6,d7,d0
        addq.l     #4,a2          : caddr+=x_blk
        XDELTA      (a2),d3,a0,d6,d7,d0

        bsr       SENDSKIP
        rts

@ss      : STILLSEND #4,d5,d3

        XVAL1      (a2),d3,a0,d6,d7,d0
        addq.l     #4,a2          : caddr+=x_blk
        XVAL1      (a2),d3,a0,d6,d7,d0
        adda.w     d5,a2          : caddr+=y_blk
        XVAL1      (a2),d3,a0,d6,d7,d0
        addq.l     #4,a2          : caddr+=x_blk
        XVAL1      (a2),d3,a0,d6,d7,d0

        bsr       SS_SKIP
        rts

@vd      : VOID      #4,d5

```



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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        clr.w      (a2)
        addq.l     #4,a2
        clr.w      (a2)          ; caddr+=x_blk
        adda.w     d5,a2          ; caddr+=y_blk
        clr.w      (a2)
        addq.l     #4,a2          ; caddr+=x_blk
        clr.w      (a2)
        rts

        ENDFUNC

        macro
        DOSTILL1      &addr

        buf_get      d6,d7          ; BUF_GET
        beq.w         @next          ; if 0 the STOP

        move.l       a1,a2          ; caddr=baddr
        add.l         &addr,a2       ; caddr+=addrs(1)
        STILL        #4,d5,d4
        bsr          STILLSKIP
        buf_rinc     a0,d6,d7       ; BUF_INC
@next
        endm

        macro
        DOVOID1      &addr

        move.l       a1,a2          ; caddr=baddr
        add.l         &addr,a2       ; caddr+=addrs(1)
        VOID         #4,d5

        endm

        macro
        DOSTILLSEND1 &addr

        buf_get      d6,d7          ; BUF_GET
        beq.w         @next          ; if 0 the STOP
        move.l       a1,a2          ; caddr=baddr
        add.l         &addr,a2       ; caddr+=addrs(1)
        buf_get      d6,d7          ; BUF_GET
        beq.s         @ss           ; if 0 then STILLSEND

        VOID         #4,d5
        bra          @next

@ss      STILLSEND  #4,d5,d4
        bar          SS_SKIP
        buf_rinc     a0,d6,d7       ; BUF_INC
@next
        endm

DOSTILL2      FUNC      EXPORT

        buf_rinc     a0,d6,d7       ; BUF_INC
        buf_get      d6,d7          ; BUF_GET
        bne.s        @cont          ; if 1 the CONT
        rts

@cont      move.l     a1,a2          ; caddr=baddr

```

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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

add.l    =    (a3).a2
STILL    #8,d5,d3      : caddr+=addrs(0)

swap     d5
exg      d4,a5

buf_rinc a0,d6,d7      : BUF_INC
DOSTILL1 4(a3)
DOSTILL1 8(a3)
DOSTILL1 12(a3)
DOSTILL1 16(a3)

swap     d5
exg      d4,a5
rts

macro
DOSEND1  &addr

    buf_get: d6,d7      : BUF_GET
    beq.w   @next      : if 0 the STOP
    move.l  a1,a2      : caddr=baddr
    add.l   &addr,a2   : caddr+=addrs(1)
    buf_get d6,d7      : BUF_GET
    beq.w   @ss        : if 0 then STILLSEND
    buf_get d6,d7      : BUF_GET
    beq.w   @vd        : if 0 then VOID

    SEND    #4,d3,d4
    bsr     SENDSKIP
    bra     @rinc

@vd      VOID          #4,d3
bra      @next

@ss      STILLSEND    #4,d3,d4
bsr     SS_SKIP
@rinc    buf_rinc      a0,d6,d7      : BUF_INC
@next

    endm

DOSEND2 FUNC    EXPORT

    buf_rinc a0,d6,d7      : BUF_INC
    buf_get  d6,d7      : BUF_GET
    bne.s    @cont      : if 1 the CONT
@next      rts

@cont      move.l a1,a2
    add.l   (a3).a2      : caddr=baddr
    buf_get d6,d7      : caddr+=addrs(0)
    beq.w   @ss        : BUF_GET
    buf_get d6,d7      : if 0 then STILLSEND
    beq.w   @vd        : BUF_GET
    beq.w   @vd        : if 0 then VOID

... SEND ...

    SEND    #8,d1,d3

    buf_rinc a0,d6,d7      : BUF_INC
    DOSEND1 4(a3)
    DOSEND1 8(a3)

```

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Engineering:KlicsCode:CompPic:KlicsDec2.a

```

DOSEND1    = 12(a3)
DOSEND1    = 16(a3)
rts

```

\*\*\* STILLSEND \*\*\*

```

?ss    STILLSEND    =8,d1,d3

```

```

    buf_rinc    a0,d6,d7    ; BUF_INC
    DOSTILLSEND1    4(a3)
    DOSTILLSEND1    8(a3)
    DOSTILLSEND1    12(a3)
    DOSTILLSEND1    16(a3)
    rts

```

\*\*\* VOID \*\*\*

```

?vd    VOID    #8,d1

```

```

    DOVOID1    4(a3)
    DOVOID1    8(a3)
    DOVOID1    12(a3)
    DOVOID1    16(a3)
    rts

```

ENDFUNC

```

macro
UVSTILLO

```

```

Low_Pass

```

```

    move.l    a1,a2    ; caddr=baddr
    LPPSTILL    #4,d5,d2,d4

```

```

Sub-band gh

```

```

    addq.l    #2,a1    ; baddr+=2 (gh band)
    bsr    DOSTILLO

```

```

Sub-band hg

```

```

    subq.l    #2,a1    ; baddr-=2 (hh band)
    add.l    a4,a1    ; caddr+=1 row (hg band)
    bsr    DOSTILLO

```

```

Sub-band gg

```

```

    addq.l    #2,a1    ; baddr+=2 (gg band)
    bsr    DOSTILLO
    sub.l    a4,a1    ; caddr-=1 row (gh band)
    addq.l    #6,a1    ; (2+) addr[0]+=x_inc

```

endm

```

macro
UVSEND0

```

```

Low_Pass

```

```

    buf_rinc    a0,d6,d7    ; BUF_INC
    buf_get    d6,d7    ; BUF_GET
    beq.w    0subs    ; if 0 then process subbands

```

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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        move.l    a1,a2                ; caddr=baddr
        SEND     #4,d5,d2
    .
    .   Sub-band gh
    .
2subs    addq.l    #2,a1                ; baddr+=2 (gh band)
        bsr      DOSEND0
    .
    .   Sub-band hg
    .
        subq.l    #2,a1                ; baddr-=2 (hh band)
        add.l     a4,a1                ; caddr+=1 row (hg band)
        bsr      DOSEND0
    .
    .   Sub-band gg
    .
        addq.l    #2,a1                ; baddr+=2 (gg band)
        bsr      DOSEND0
        sub.l     a4,a1                ; caddr-=1 row (gh band)
        addq.l    #6,a1                ; (2*) addr[0]-=x_inc
    .
        endm

.....
    .
    .   Decoder functions:
    .
    .   Klics2D1Still, Klics2D1Send
    .
    .
    .
Klics2D1Still    FUNC    EXPORT
    .
    .   Klics2D1Still(short *dst, long size_x, long size_y, long lpfbits, short *norms
    .
PS        RECORD      8
dst       DS.L         1
size_x    DS.L         1
size_y    DS.L         1
lpfbits   DS.L         1
norms     DS.L         1
ptr       DS.L         1
data      DS.L         1
bno       DS.L         1
        ENDR
    .
LS        RECORD      0,DECR
x_lim     DS.L         1                ; x counter termination      row_start=
x_linc    DS.L         1                ; x termination increment      1 row
y_linc0   DS.L         1                ; y counter increment          4 rows
y_linc1   DS.L         1                ; y counter increment          7 rows
y_lim     DS.L         1                ; y counter termination        area
LSize     EQU
        ENDR
    .
    .   d0/d1 - spare
    .   d2 - step 0 (HH)
    .   d3 - step 0
    .   d4 - lpfbits
    .   d5 - y_blk
    .   d6 - data      (bit stream)
    .   d7 - bno       (bit pointer)
    .

```

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Engineering:KllicsCode:CompPict:KllicsDec2.a

```

*   a0 - ptr      (bit buffer)
*   a1 - baddr    (block address)
*   a2 - caddr    (coeff address)
*   a3 - x_lim
*   a4 - x_linc
*   a5 - y_inc0
*
*   link          a6,*LS.LSize          : locals
*   movem.l       d4-d7/a3-a5,-(a7)     : store registers
*
*   Load Bit Buffer
*
*   move.l        PS.data(a6),a0        : a0=&data
*   move.l        (a0),d6                : data=>a0
*   move.l        PS.bmo(a6),a0         : a0=&mask
*   move.l        (a0),d7                : mask=>a0
*   move.l        PS.ptr(a6),a0         : a0=&ptr
*   move.l        (a0),a0                : a0=ptr
*
*   Set Up Block Counters
*
*   move.l        PS.dst(a6),a1          : a1=image
*   move.l        PS.size_x(a6),d0       : d0=size_x
*   add.l         d0,d0                  : in shorts
*   move.l        d0,LS.x_linc(a6)       : x_linc=1 row
*   move.l        PS.size_y(a6),d1       : d1=size_y
*   muls.w        d0,d1                  : d1=d0 (area)
*   add.l         a1,d1                  : d1=>image
*   move.l        d1,LS.y_lim(a6)        : y_lim=d1
*   move.l        d0,d2                  : d2=d0 (1 row)
*   add.l         d0,d0                  : d0*=2 (2 rows)
*   move.l        d0,d3                  : y_blk=d0
*   subq.l        #4,d3                  : y_blk->x_blk
*   add.l         d0,d0                  : d0*=2 (4 rows)
*   move.l        d0,LS.y_inc0(a6)       : y_inc0=d0
*   add.l         d0,d0                  : d0*=2 (8 rows)
*   sub.l         d2,d0                  : d0->d2 (7 rows)
*   move.l        d0,LS.y_incl(a6)       : y_incl=d0
*
*   move.l        PS.norms(a6),a2        : GetNorm pointer
*   move.l        (a2),d2                : read normal
*   move.l        4(a2),d3               : read normal
*   move.l        PS.lpfbits(a6),d4      : read lpfbits
*   move.l        LS.x_linc(a6),a4       : read x_linc
*   move.l        LS.y_inc0(a6),a5       : read y_inc0
*
0y   move.l       a4,a3                  : x_lim=x_linc
      add.l       a1,a3                  : x_lim->baddr
0x   UVSTILL0
      UVSTILL0
      add.l       a5,a1                  : (2) addr[0]+>y_inc
      cmp.l       LS.y_lim(a6),a1       : (2+) addr[0]-limit?
      bge.w       0last                 : if half height
      sub.l       #16,a1                : pointer=blk(0,1)
      UVSTILL0
      UVSTILL0
0last sub.l       a5,a1                  : (2) addr[0]+>y_inc
*
      cmp.l       a3,a1                  : (2+) addr[0]-limit?
      blt.w       0x                    : (4) if less then loopX
      add.l       LS.y_incl(a6),a1       : (2+) addr[0]+>y_inc
      cmp.l       LS.y_lim(a6),a1       : (2+) addr[0]-limit?
      blt.w       0y                    : (4) if less then loopY

```

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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

*
*   Save Bit Buffer
*
        move.l    PS.data(a6),a2        ; spare=&data
        move.l    d6,(a2)                ; update data
        move.l    PS.bno(a6),a2         ; spare=&bno
        move.l    d7,(a2)                ; update bno
        move.l    PS.ptr(a6),a2         ; spare=&ptr
        move.l    a0,(a2)                ; update ptr
*
        movem.l   (a7)+,d4-d7/a3-a5     ; restore registers
        unlk      a6                     ; remove locals
        rts                                ; return
*
        ENDFUNC
*-----*
klics2D1Send    FUNC    EXPORT
*
*   Klics2D1Send(short 'dst, long size_x, long size_y, short 'norms, unsigned long
*
PS      RECORD      8
dst     DS.L         1
size_x  DS.L         1
size_y  DS.L         1
norms   DS.L         1
ptr     DS.L         1
data    DS.L         1
bno     DS.L         1
        ENDR
*
LS      RECORD      0,DECR
x_lim   DS.L         1
x_linc  DS.L         1
y_inc0  DS.L         1
y_incl  DS.L         1
y_lim   DS.L         1
LSize   EQU          *
        ENDR
*
*   d0/d1 - spare
*   d2 - step 0 (MH)
*   d3 - step 0
*   d4 - y_inc0
*   d5 - y_blk
*   d6 - data (bit stream)
*   d7 - bno (bit pointer)
*
*   a0 - ptr (bit buffer)
*   a1 - baddr (block address)
*   a2 - caddr (coeff address)
*   a3 - x_lim
*   a4 - x_linc
*   a5 - y_lim
*
        link      a6,#LS.LSize          ; locals
        movem.l   d4-d7/a3-a5,-(a7)     ; store registers
*
*   Load Bit Buffer
*
        move.l    PS.data(a6),a0        ; a0=&data
        move.l    (a0),d6                ; data=&a0
        move.l    PS.bno(a6),a0         ; a0=&mask
        move.l    (a0),d7                ; mask=&a0

```

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Engineering:KlicsCode:CompPict:KlicsDec2.a

```

move.l    PS.ptr(a6),a0      ; a0=&ptr
move.l    (a0),a0            ; a0=ptr
.
.  Set Up Block Counters
.
move.l    PS.dst(a6),a1      ; a1=image
move.l    PS.size_x(a6),d0   ; d0=size_x
add.l     d0,d0              ; in shorts
move.l    d0,LS.x_linc(a6)   ; x_linc=1 row
move.l    PS.size_y(a6),d1   ; d1=size_y
muls.w    d0,d1              ; d1=d0 (area)
add.l     a1,d1              ; d1+=image
move.l    d1,LS.y_lim(a6)    ; y_lim=d1
move.l    d0,d2              ; d2=d0 (1 row)
add.l     d0,d2              ; d0*=2 (2 rows)
move.l    d0,d5              ; copy to d5
subq.l    #4,d5              ; subtract x_blk
add.l     d0,d0              ; d0*=2 (4 rows)
move.l    d0,LS.y_inc0(a6)   ; y_inc0=d0
add.l     d0,d0              ; d0*=2 (8 rows)
sub.l     d2,d0              ; d0-=d2 (7 rows)
move.l    d0,LS.y_incl(a6)   ; y_incl=d0

move.l    PS.norms(a6),a2    ; GetNorm pointer
move.l    (a2),d2            ; read normal
move.l    4(a2),d3           ; read normal
move.l    LS.x_linc(a6),a4    ; read x_linc
move.l    LS.y_inc0(a6),d4    ; read y_inc0
move.l    LS.y_lim(a6),a5     ; read y_lim

0y      move.l    a4,a3      ; x_lim=x_linc
add.l     a1,a3            ; x_lim+=baddr
0x      UVSEND0    ; process UV block 0.0
UVSEND0    ; process UV block 1.0
add.l     d4,a1            ; (2) addr(0)+y_inc
cmp.l     a5,a1            ; (2) addr(0)-limit?
bge.w     @last           ; if half height
sub.l     #16,a1           ; pointer=blk(0.1)
UVSEND0    ; process UV block 0.1
UVSEND0    ; process UV block 1.1
@last    sub.l     d4,a1      ; (2) addr(0)+y_inc

cmp.l     a3,a1            ; (2) addr(0)-limit?
blt.w     0x              ; (4) if less then loopX
add.l     LS.y_incl(a6),a1  ; (2+) addr(0)+y_inc
cmp.l     a5,a1            ; (2) addr(0)-limit?
blt.w     0y              ; (4) if less then loopY
.
.  Save Bit Buffer
.
move.l    PS.data(a6),a2     ; spare=&data
move.l    d6,(a2)           ; update data
move.l    PS.bno(a6),a2     ; spare=&bno
move.l    d7,(a2)           ; update bno
move.l    PS.ptr(a6),a2     ; spare=&ptr
move.l    a0,(a2)           ; update ptr
.
move.l    (a7)+,d4-d7/a3-a5  ; restore registers
unlk     a6                ; remove locals
rts      ; return
.
ENDFUNC
-----

```

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Engineering:KlacsCode:CompPict:KlacsDec2.a

```

Klacs3D2Still FUNC EXPORT
: Klacs3D2Still(short *dst, long size_x, long size_y, long lpfbits, short *norms
:
PS      RECORD      8
dst     DS.L         1
size_x  DS.L         1
size_y  DS.L         1
lpfbits DS.L         1
norms   DS.L         1
ptr     DS.L         1
data    DS.L         1
bno     DS.L         1
sub_cab DS.L         1
        ENDR
:
LS      RECORD      0, DECR
y_blk0  DS.L         1          ; y inter-block increment    2 rows - 4
y_blk1  DS.L         1          ; y inter-block increment    4 rows - 8
x_inc   DS.L         1          ; x counter increment       16
x_lim   DS.L         1          ; x counter termination     row_start+
x_linc  DS.L         1          ; x termination increment   1 row
y_inc   DS.L         1          ; y counter increment       7 rows
y_lim   DS.L         1          ; y counter termination     area
LSize   EQU          *
        ENDR
:
: d0/d1 - spare
: d2 - step 2HH
: d3 - step 1
: d4 - step 0/lpfbits
: d5 - y_blk0, y_blk1
: d6 - data (bit stream)
: d7 - bno (bit pointer)
:
: a0 - ptr (bit buffer)
: a1 - baddr (block address)
: a2 - caddr (coeff address)
: a3 - addrs (tree addresses)
: a4 - x_lim (x counter termination)
: a5 - lpfbits/step 0
:
: link      a6, #LS.LSize          ; locals
: movem.l   d4-d7/a3-a5, -(a7)    ; store registers
:
: Load Bit Buffer
:
: move.l     PS.data(a6), a0        ; a0=&data
: move.l     (a0), d6              ; data=*a0
: move.l     PS.bno(a6), a0        ; a0=&mask
: move.l     (a0), d7              ; mask=*a0
: move.l     PS.ptr(a6), a0        ; a0=&ptr
: move.l     (a0), a0              ; a0=ptr
:
: Set Up Block Counters
:
: move.l     PS.dst(a6), a1        ; a1=image
: move.l     PS.size_x(a6), d0     ; d0=size_x
: move.l     #16, LS.x_inc(a6)    ; save x_inc
: add.l     d0, d0                ; in shorts
: move.l     d0, LS.x_linc(a6)    ; x_linc=1 row
: move.l     PS.size_y(a6), d1    ; d1=size_y
: muls.w     d0, d1               ; d1*=d0 (area)

```





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Engineering:KlicsCode:CompPict:KlicsDec2.a

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```

    movem.l    (a7),d4-d7/a3-a5    ; restore registers
    unlk       a6                  ; remove locals
    rts                          ; return
    ENDFUNC
    -----
    Klics3D2Send    FLNC    EXPORT
    Klics3D2Send(short *dst, long size_x, long size_y, short *norms, unsigned long
    PS            RECORD      8
    dst           DS.L         1
    size_x        DS.L         1
    size_y        DS.L         1
    norms         DS.L         1
    ptr           DS.L         1
    data          DS.L         1
    bno           DS.L         1
    sub_tab       DS.L         1
    ENDR
    LS            RECORD      0,DECR
    y_blk0        DS.L         1          ; y inter-block increment    2 rows - 4
    y_blk1        DS.L         1          ; y inter-block increment    4 rows - 8
    x_inc         DS.L         1          ; x counter increment        16
    x_lim         DS.L         1          ; x counter termination      row_start+
    x_linc        DS.L         1          ; x termination increment    1 row
    y_inc         DS.L         1          ; y counter increment        7 rows
    y_lim         DS.L         1          ; y counter termination      area
    LSize         EQU          *
    ENDR
    d0 - spare
    d1 - y_blk1
    d2 - step 2HH
    d3 - step 1
    d4 - step 0
    d5 - y_blk0
    d6 - data      (bit stream)
    d7 - bno       (bit pointer)
    a0 - ptr       (bit buffer)
    a1 - baddr     (block address)
    a2 - caddr     (coeff address)
    a3 - addrs     (tree addresses)
    a4 - x_lim     (x counter termination)
    link          a6,#LS.LSize          ; locals
    movem.l       d4-d7/a3-a5,-(a7)     ; store registers
    Load Bit Buffer
    move.l        PS.data(a6),a0        ; a0=&data
    move.l        (a0),d6               ; data+*a0
    move.l        PS.bno(a6),a0         ; a0=&mask
    move.l        (a0),d7               ; mask+*a0
    move.l        PS.ptr(a6),a0         ; a0=&ptr
    move.l        (a0),a0               ; a0=ptr
    Set Up Block Counters
    move.l        PS.dst(a6),a1         ; a1=image

```



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Engineering:KlacsCode:CompPict:KlacsDec2.1

```

end      move.l    PS.data(a6),a2      : spare=&data
         move.l    c6,(a2)              : update data
         move.l    PS.bno(a6),a2       : spare=&bno
         move.l    d7,(a2)             : update bno
         move.l    PS.ptr(a6),a2       : spare=&ptr
         move.l    a0,(a2)             : update ptr
         .
         movem.l   (a7)+,d4-d7/a3-a5   : restore registers
         unlink    a6                  : remove locals
         rts                          : return
         .
         ENDFUNC
-----
         END

```

Engineering:KlicsCode:CcmpPict:KlicsDec.c

```

.....
.
.  © Copyright 1993 KLIKS Limited
.  All rights reserved.
.
.  Written by: Adrian Lewis
.
.....
/*
.  Importing raw Klics binary files
.
.  Stand-alone version
*/

#include "Bits3.h"
#include "Klics.h"
#include "KlicsHeader.h"

typedef char Boolean;

/* If bool true the negate value */
#define negif(bool,value) ((bool)?-(value):(value))

extern void HaarBackward();
extern void Daub4Backward(short *data,int size[2],int oct_src);
extern void TestTopBackward(short *data,int size[2],int oct_src);
extern void TestBackward(short *data,int size[2],int oct_src);
extern void KLICSDCHANNEL(short *dst, long octs, long size_x, long size_y, long
/* Use the bit level file macros (Bits2.h) */
/* buf_use: */

/* Huffman decode a block */
#define HuffDecLev(lev,buf) \
    lev[0]=HuffDecode(buf); \
    lev[1]=HuffDecode(buf); \
    lev[2]=HuffDecode(buf); \
    lev[3]=HuffDecode(buf);

/* Fixed length decode block of integers */
#define IntDecLev(lev,lpf_bits,buf) \
    lev[0]=IntDecode(lpf_bits,buf); \
    lev[1]=IntDecode(lpf_bits,buf); \
    lev[2]=IntDecode(lpf_bits,buf); \
    lev[3]=IntDecode(lpf_bits,buf);

/* Reverse quantize difference block */
#define RevOntDelta(new,old,lev,shift) \
    new[0]=old[0]+(lev[0]<<shift)-(lev[0]!=0?negif(lev[0]<0,(1<<shift)-1>>1):0); \
    new[1]=old[1]+(lev[1]<<shift)-(lev[1]!=0?negif(lev[1]<0,(1<<shift)-1>>1):0); \
    new[2]=old[2]+(lev[2]<<shift)-(lev[2]!=0?negif(lev[2]<0,(1<<shift)-1>>1):0); \
    new[3]=old[3]+(lev[3]<<shift)-(lev[3]!=0?negif(lev[3]<0,(1<<shift)-1>>1):0);

/* Reverse quantize block */
#define RevOnt(new,lev,shift) \
    new[0]=(lev[0]<<shift)+(lev[0]!=0?negif(lev[0]<0,(1<<shift)-1>>1):0); \
    new[1]=(lev[1]<<shift)+(lev[1]!=0?negif(lev[1]<0,(1<<shift)-1>>1):0); \
    new[2]=(lev[2]<<shift)+(lev[2]!=0?negif(lev[2]<0,(1<<shift)-1>>1):0); \
    new[3]=(lev[3]<<shift)+(lev[3]!=0?negif(lev[3]<0,(1<<shift)-1>>1):0);

#define RevOntLPP(new,lev,shift) \
    new[0]=(lev[0]<<shift)+((1<<shift)-1>>1); \
    new[1]=(lev[1]<<shift)+((1<<shift)-1>>1); \
    new[2]=(lev[2]<<shift)+((1<<shift)-1>>1); \

```

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Engineering:KlicsCode:CompPict:KlicsDec.c

```

new[3]=Prev[3]<<shift)+((1<<shift.-1)>>1);

/* Read a difference block and update memory */
#define DoXferDelta(addr,old,new,lev,dst,shift,mode,oct,rmode,buf) \
    HuffDecLev(lev,buf); \
    RevCntDelta(new,old,lev,shift) \
    PutData(addr,new,dst); \
    mode[oct]=oct==0?M_STOP:rmode;

/* Read a block and update memory */
#define DoXfer(addr,new,lev,dst,shift,mode,oct,rmode,buf) \
    HuffDecLev(lev,buf); \
    RevCnt(new,lev,shift) \
    PutData(addr,new,dst); \
    mode[oct]=oct==0?M_STOP:rmode;

/* Function Name:  IntDecode
 * Description:    Read a integer from bit file
 * Arguments:     bits - bits/integer now signed
 * Returns:       integer value
 */

short  IntDecode(short bits,Buf buf)
{
    int      i, lev=0, mask=1;
    Boolean sign;

    /* Hardware compatatble version */
    buf_rinc(buf);
    sign=buf_get(buf);
    for(i=0;i<bits-1;i++) {
        buf_rinc(buf);
        if (buf_get(buf)) lev |= mask;
        mask <<= 1;
    }
    if (sign) lev= -lev;
    return(lev);
}

/* Function Name:  HuffDecode
 * Description:    Read a Huffman coded integer from bit file
 * Returns:       integer value
 */

short  HuffDecode(Buf buf)
{
    short  lev=0, i;
    Boolean neg;

    /* Hardware compatatble version */
    buf_rinc(buf);
    if (buf_get(buf)) {
        buf_rinc(buf);
        neg=buf_get(buf);
        do {
            buf_rinc(buf);
            lev++;
        } while (lev<7 && !(buf_get(buf)));
        if (!(buf_get(buf))) {
            for(lev=0,i=0;i<7;i++) {
                lev<<=1;
                buf_rinc(buf);
            }
        }
    }
    if (neg) lev= -lev;
    return(lev);
}

```



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Engineering:KlicsCode:CompPict:KlicsDec.c

```

    )
    ) else
        mode[oct]=M_STOP;
        break;
    case M_STILL:
        buf_rinc(buf);
        if (buf_get(buf)) { DoXfer(addr,new,lev,dst,frmh->quantizer(octs-oct));
        else mode[oct]=M_STOP;
        break;
    case M_LPFIM_STILL:
        IntDecLev(lev,seqh->precision-frmh->quantizer(0),buf);
        RevOntLPF(new,lev,frmh->quantizer(0));
        PutData(addr,new,dst);
        mode[oct]=M_QUIT;
        break;
    case M_LPFIM_SEND:
        buf_rinc(buf);
        if (buf_get(buf)) {
            GetData(addr,old,dst);
            HuffDecLev(lev,buf);
            RevOntDelta(new,old,lev,frmh->quantizer(0));
            PutData(addr,new,dst);
        }
        mode[oct]=M_QUIT;
        break;
    }
    switch(mode[oct]) {
    case M_STOP:
        StopCounters(mode,oct,mask,blk,x,y,octs);
        break;
    case M_QUIT:
        break;
    default:
        DownCounters(mode,oct,mask,blk);
        break;
    }
    } while (mode[oct]!=M_QUIT);
}

void KlicsDecUV(short *dst, int octs, int size[2], KlicsFrameHeader *frmh,
KlicsSeqHeader *seqh, Buf buf)
{
    int oct, mask, x, y, X, Y, sub, step=4<<octs, blk[4], mode[4], base_mode=1;
    Blk addr, new, old, lev;

    for(Y=0;Y<size[1];Y+=step)
    for(X=0;X<size[0];X+=step)
    for(y=Y;y<size[1] && y<Y+step;y+=step>>1)
    for(x=X;x<size[0] && x<X+step;x+=step>>1)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
            case M_VOID:
                GetData(addr,old,dst);
                if (BlkZero(old)) mode[oct]=M_STOP;
                else { DoZero(addr,dst,mode,oct); }
                break;
            case M_SENDIM_STILL:

```



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Engineering:KlicsCode:CompPict:KlicsDec.c

```

    buf_rinc(buf);
    if (buf_get(buf)) {
        buf_rinc(buf);
        if (buf_get(buf)) {
            DoZero(addr,dst,mode,oct);
        } else {
            DoXfer(addr,new,lev,dst,frmh->quantizer(octs-oct),mode,oct,M_S
        )
    } else
        mode[oct]=M_STOP;
    break;
case M_SEND:
    buf_rinc(buf);
    if (buf_get(buf)) {
        buf_rinc(buf);
        if (buf_get(buf)) {
            buf_rinc(buf);
            if (buf_get(buf)) {
                GetData(addr,old,dst);
                DoXferDelta(addr,old,new,lev,dst,frmh->quantizer(octs-oct)
            ) else {
                DoZero(addr,dst,mode,oct);
            }
        } else {
            DoXfer(addr,new,lev,dst,frmh->quantizer(octs-oct),mode,oct,M_S
        )
    } else
        mode[oct]=M_STOP;
    break;
case M_STILL:
    buf_rinc(buf);
    if (buf_get(buf)) { DoXfer(addr,new,lev,dst,frmh->quantizer(octs-oct),;
    else mode[oct]=M_STOP;
    break;
case M_LPFIM_STILL:
    IntDecLev(lev,seqh->precision-frmh->quantizer(0),buf);
    RevOntLpf(new,lev,frmh->quantizer(0));
    PutData(addr,new,dst);
    mode[oct]=M_QUIT;
    break;
case M_LPFIM_SEND:
    buf_rinc(buf);
    if (buf_get(buf)) {
        GetData(addr,old,dst);
        HuffDecLev(lev,buf);
        RevOntDelta(new,old,lev,frmh->quantizer(0));
        PutData(addr,new,dst);
    }
    mode[oct]=M_QUIT;
    break;
}
switch(mode[oct]) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode[oct]!=M_QUIT);
}

```

Engineering:KlicsCode:CompPict:KlicsDec.c

```

)

/* Function Name: KlicsDecode
 * Description:   Decode a frame to YUV (de)transformed image
 * Arguments:    src - destination result
 *               dst - transformed destination memory (and cld for videos)
 * Returns:      whether this frame was skipped
 */

extern void KLCOPY(short *dst, short *src, long area);
extern void KLHALF(short *dst, short *src, long size_0, long size_1);
extern void KLICS3D2SEND(short *dst, long size_x, long size_y, short norms[4]);
extern void KLICS2D1STILL(short *dst, long size_x, long size_y, long lpfbits);
extern void KLICS3D2STILL(short *dst, long size_x, long size_y, long lpfbits);
extern void KLICS2D1SEND(short *dst, long size_x, long size_y, short norms[4]);

#define flag_tree 0x1
#define flag_wave 0x2

void KlicsDecode(short *src[3], short *dst[3], KlicsSeqHeader *seqh, KlicsFrameH
(
    long channel, i;
    short norms[4][2];
    unsigned long sync1, sync2;

    for(i=0; i<4; i++) {
        norms[i][0] = (1<<frmh->quantizer[i]-1)-1;
        norms[i][1] = frmh->quantizer[i];
    }
    buf_rinit(buf);
    if (0 != (flags & flag_tree)) {
        sync1 = GetTimerValue(&sync1);
        for(channel=0; channel<seqh->channels; channel++) {
            int size[2] = (seqh->sequence_size[0]>>(channel==0?0:seqh->sub_sampl
                seqh->sequence_size[1]>>(channel==0?0:seqh->sub_sample[1])
                tree_size[2] = (size[0]>>scale[0], size[1]>>scale[0]);
                octs = seqh->octaves[channel==0?0:1];

#ifdef HQ
            if (0 != (frmh->flags & KFH_INTRA)) {
                KLZERO(dst[channel], tree_size[0]*tree_size[1]);
                KLICSDCHANNEL(dst[channel], octs-1, tree_size[0], tree_size[1], (long)(seq
            if (channel==0) KlicsDecY(dst[channel], octs, tree_size, frmh, seqh, buf);
            else KlicsDecUV(dst[channel], octs, tree_size, frmh, seqh, buf);
        } else
            long sub_tab[15] = {4, 2, 10, 2+8*tree_size[0], 10+8*tree_size[0],
                4*tree_size[0], 2*tree_size[0], 8+2*tree_size[0], 10*tree_siz
                4+4*tree_size[0], 2+2*tree_size[0], 10+2*tree_size[0], 2+10*t

            if (0 != (frmh->flags & KFH_INTRA)) {
                KLZERO(dst[channel], tree_size[0]*tree_size[1]);
                if (octs==3)
                    KLICS3D2STILL(dst[channel], tree_size[0], tree_size[1], (long)(se
                else
                    KLICS2D1STILL(dst[channel], tree_size[0], tree_size[1], (long)(se
            } else
                if (octs==3)
                    KLICS3D2SEND(dst[channel], tree_size[0], tree_size[1], &norms, &bu
                else
                    KLICS2D1SEND(dst[channel], tree_size[0], tree_size[1], &norms, &bu
        }
    }
    sync2 = GetTimerValue(&sync2);

```



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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/

/*
 *  Klics Codec
 */

#include "ImageCodec.h"
#include <FixMath.h>
#include <Errors.h>
#include <Packages.h>

#ifdef PERFORMANCE
#include <Perf.h>
extern TP2PerfGlobals ThePGlobals;
#endif

#ifdef DEBUG
#define DebugMsg(val)    DebugStr(val)
#else
#define DebugMsg(val)
#endif

#define WT_Haar    0
#define WT_Daub4   1

#define None      0
#define Use8      1
#define Use16     2
#define Use32     3
#define UseF32    4

/* Version information */

#define KLICS_CODEC_REV      1
#define codecInterfaceVersion 1 /* high word returned in component GetVersion */

#define klicsCodecFormatName  "Klics"
#define klicsCodecFormatType  "klic"

pascal ComponentResult
KlicsCodec(ComponentParameters *params, char **storage);

pascal ComponentResult
KLOpenCodec(ComponentInstance self);

pascal ComponentResult
KLCloseCodec(Handle storage, ComponentInstance self);

pascal ComponentResult
KLCanDoSelector(short selector);

pascal ComponentResult
KLGetVersion();

pascal ComponentResult
KLGetCodecInfo(Handle storage, CodecInfo *info);

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

pascal ComponentResult
KLGetMaxCompressionSize(Handle storage, PixmapHandle src, const Rect *srcRect, short
    CodecQ quality, long *size);

pascal ComponentResult
KLGetCompressedImageSize(Handle storage, ImageDescriptionHandle desc, Ptr data, long
    DataProcRecordPtr dataProc, long *size);

pascal ComponentResult
KLPreCompress(Handle storage, register CodecCompressParams *p);

pascal long
KLPreDecompress(Handle storage, register CodecDecompressParams *p);

pascal long
KLBandDecompress(Handle storage, register CodecDecompressParams *p);

pascal long
KLBandCompress(Handle storage, register CodecCompressParams *p);

pascal ComponentResult
KLGetCompressionTime(Handle storage, PixmapHandle src, const Rect *srcRect, short dep
    CodecQ *spatialQuality, CodecQ *temporalQuality, unsigned long *time);

/* Function: KlicsCodec
 * Description: KlicsCodec main dispatcher
 */

#ifdef DECODER
pascal ComponentResult
KlicsDecoder(ComponentParameters *params, char **storage)
#else
#ifdef ENCODER
pascal ComponentResult
KlicsEncoder(ComponentParameters *params, char **storage)
#else
pascal ComponentResult
KlicsCodec(ComponentParameters *params, char **storage)
#endif
#endif
(
    CSErr err;

    switch ( params->what ) {
    case kComponentOpenSelect:
        err=CallComponentFunction(params, (ComponentFunction) KLOpenCodec); break;

    case kComponentCloseSelect:
        err=CallComponentFunctionWithStorage(storage, params, (ComponentFunction) KLC
        case kComponentCanDoSelect:
            err=CallComponentFunction(params, (ComponentFunction) KLCanDoSelector); brea
        case kComponentVersionSelect :
            err=CallComponentFunction(params, (ComponentFunction) KLGetVersion); break;

#ifdef DECODER
        case codecPreCompress:
        case codecBandCompress:
            err=codecUnimpErr; break;
    } else
        case codecPreCompress:

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

    err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLP

    case codecBandCompress:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLB
#endif
#ifdef ENCODER
    case codecPreDecompress:
    case codecBandDecompress:
        err=codecUnimpErr; break;
#else
    case codecPreDecompress:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLP

    case codecBandDecompress:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLB
#endif
    case codecCDSequenceBusy:
        err=0; break;          /* our codec is never asynchronously busy

    case codecGetCodecInfo:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetCompressedImageSize:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetMaxCompressionSize:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetCompressionTime:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetSimilarity:
        err=codecUnimpErr; break;

    case codecTrimImage:
        err=codecUnimpErr; break;

    default:
        err=paramErr; break;
    )
    if (err!=noErr)
        DebugMsg('\pCodec Error');
    return(err);
}

#include <Memory.h>
#include <Resources.h>
#include <OSUtils.h>
#include <SysEqu.h>

#include <StdIO.h>
#include <Time.h>

#include <Strings.h>
#include <String.h>
#include "BitsJ.h"
#include "KlicsHeader.h"
#include "KlicsEncode.h"

void DebugString(char *string)
{
    DebugStr(string);
}

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

extern short gResRef;

```
typedef struct {
    CodecInfo **info;
    Ptr tab(4);
    short use(4);
} SharedGlobals;
```

```
typedef struct {
    KlicsERec kle; /* Encoding parameters */
    short *src(3); /* YUV Frame buffer */
    short *dst(3); /* YUV Frame buffer */
    Ptr pixmap; /* Encoded pixmap data */
    long size; /* Size of Previous Frame Buffer */
    long using; /* Which lookup table are we using for colour */
    long scale(3); /* Tree, Wave, Out scales 0=Original, -1=Double */
    unsigned long prev_frame; /* Previous frame number */
    unsigned long real_frame; /* Previous real frame (no skips) */
    unsigned long dpy_frame; /* Previous displayed frame */
    unsigned long run_frame; /* First frame in play sequence */
    unsigned long sys_time; /* System overhead for previous frame */
    unsigned long tree_time; /* Typical tree decode time (not skip) */
    unsigned long wave_time; /* Typical wavelet transform time */
    unsigned long dpy_time; /* Typical display time */
    unsigned long run_time; /* Time of first run frame */
    unsigned long key_time; /* Time at last key frame */
    unsigned long sync_time; /* Sync time */
    Boolean out(15); /* Displayed? */
    SharedGlobals *sharedGlob;
} Globals;
```

/\* Scaling scenarios: Tree Wave Out

```

* 1 1 0: Internal calculations are Quarter size, output Original size (interpo
* 1 1 1: Internal calculations are Quarter size, output Quarter size
* 0 1 1: Internal calculations are Original size, output Quarter size
* 0 0 0: Internal calculations are Original size, output Original size
* 0 0 -1: Internal calculations are Original size, output Double size
*/
```

void KLDeallocate(Globals \*\*glob);

/\* Klics Function Definitions \*/

```
extern int KlicsEncode(short *src(3), short *dst(3), KlicsE kle);
extern Boolean KlicsDecode(short *src(3), short *dst(3), KlicsSeqHeader *seqh, Klics
    long mode, long scale(3), unsigned long *tree, unsigned long *wave);
```

```
/*.....
*
* Memory allocation/deallocation routines
*
*.....*/
```

OSErr

MemoryError()

```
{
    OSErr theErr;
```

#ifdef DEBUG

```
    if (0 != (theErr = MemError()))
        DebugStr("\pMemoryError");
```

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Engineering:KlacsCode:CompPact:KlacsCodec.c

```

#endif
    return(theErr);
}

OSErr
FreePtr(Ptr *ptr)
{
    OSErr theErr=0;

    if (*ptr!=nil) {
        DisposePtr(*ptr);
        *ptr=nil;
        theErr=MemoryError();
    }
    return(theErr);
}

#define FreePointer(handle,err) \
    if (noErr!=(err=FreePtr((Ptr*)&handle))) return(err)

extern OSErr Colour8(Ptr *);
extern OSErr Colour16(Ptr *);
extern OSErr UV32Table(Ptr *);
extern OSErr RGBTable(Ptr *);

OSErr
KLGetTab(Globals **glob,long new)
{
    OSErr theErr=0;
    SharedGlobals *sGlob=(*glob)->sharedGlob;
    long old=(*glob)->using;

    if (old!=new) {
        if (old!=None) {
            sGlob->use[old]--;
            if (sGlob->use[old]==0) {
                FreePointer(sGlob->tab[old],theErr);
            }
        }

        if (new!=None) {
            if (sGlob->use[new]==0)
                switch(new) {
                    #ifndef ENCODER
                    case Use8:
                        if (noErr!=(theErr=Colour8(&sGlob->tab[new])))
                            return(theErr);
                        break;
                    case Use16:
                        if (noErr!=(theErr=Colour16(&sGlob->tab[new])))
                            return(theErr);
                        break;
                    case Use32:
                        if (noErr!=(theErr=UV32Table(&sGlob->tab[new])))
                            return(theErr);
                        break;
                    #endif
                    #ifndef DECODER
                    case UseF32:
                        if (noErr!=(theErr=RGBTable(&sGlob->tab[new])))
                            return(theErr);
                        break;
                    #endif
                }
        }
    }
}

```



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Engineering:KlicsCode:CompFict:KlicsCodec.c

```

*endif
    )
    (*glob)->using+new;
    sGlob->use[new-1]--;
}
return(theErr);

OSErr
KLFree(Globals **glob)
{
    OSErr theErr=0;

    FreePointer((*glob)->src[0],theErr);
    FreePointer((*glob)->dst[0],theErr);
    FreePointer((*glob)->pixmap,theErr);
    (*glob)->size=0;
    return(theErr);
}

#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr)=(type)NewPtr(size)) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr)=(type)NewPtr(size)) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

ComponentResult
KLMalloc(Globals **glob, short height, short width, long pixelSize)
{
    long    ysize,uvsize;
    THz     saveZone;

    ysize=(long)height * (long)width * (long)sizeof(short);
    uvsize = ysize>>2;

    if ((*glob)->size != ysize) {
        KLFree(glob);
        (*glob)->size = ysize;
        (*glob)->prev_frame=-1; /* frame doesn't contain valid data */

        /* Keep Src and Dst separate because of their large sizes */

        ysize=(long)height * (long)width * (long)sizeof(short) >> 2*(*glob)->scale
        uvsize = ysize>>2;
        NewPointer((*glob)->src[0],short *,ysize-uvsize-uvsize+16);
        (*glob)->src[1] = (short *)(((long)(*glob)->src[0] + ysize + 3L) & 0xFFFF
        (*glob)->src[2] = (short *)(((long)(*glob)->src[1] + uvsize + 3L) & 0xFFFF

        ysize=(long)height * (long)width * (long)sizeof(short) >> 2*(*glob)->scale
        uvsize = ysize>>2;
        NewPointer((*glob)->dst[0],short *,ysize+uvsize-uvsize+16);
        (*glob)->dst[1] = (short *)(((long)(*glob)->dst[0] + ysize + 3L) & 0xFFFF
        (*glob)->dst[2] = (short *)(((long)(*glob)->dst[1] + uvsize + 3L) & 0xFFFF

```

```

                                Engineering:KlicsCode:CompPict:KlicsCodec.c
    }
    NewPointer((**glob)->pixmap.Ptr.pixelSize/8*height*width+1);
    return(noErr);
}

OSErr
ResourceError()
{
    OSErr theErr;

#ifdef DEBUG
    if (0!==(theErr=ResourceError()))
        DebugStr("\pResourceError");
#endif
    return(theErr);
}

#ifdef COMPONENT
#define ResErr(resfile,err) \
    if (0!==(err=ResourceError())) { \
        if (resfile!=0) CloseComponentResFile(resfile); \
        return(err); \
    }
#else
#define ResErr(resfile,err) \
    if (0!==(err=ResourceError())) { \
        return(err); \
    }
#endif

ComponentResult
KLOpenInfoRes(ComponentInstance self, Handle *info)
{
#pragma unused(self)
    short resFile=0;
    OSErr theErr=noErr;

    if (*info) {
        DisposHandle(*info);
        *info=nil;
    }
#ifdef COMPONENT
    resFile=OpenComponentResFile((Component)self);
    ResErr(resFile,theErr);
#else
    UseResFile(gResRef);
#endif
    *info=Get1Resource(codecInfoResourceType,128);
    *info=Get1Resource(codecInfoResourceType,129);
    ResErr(resFile,theErr);
    LoadResource(*info);
    ResErr(resFile,theErr);
    DetachResource(*info);
#ifdef COMPONENT
    CloseComponentResFile(resFile);
#endif
    return(theErr);
}

pascal ComponentResult
KLOpenCodec(ComponentInstance self)
{
    Globals **glob;

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

SharedGlobals  *sGlob;
THz            saveZone;
Boolean        inAppHeap;
ComponentResult result = noErr; -
short         resFile=CurResFile();

DebugMsg("\pOpen Codec - begin");
if ( (glob = (Globals **)NewHandleClear(sizeof(Globals))) == nil ) (
    return(MemoryError());
) else HNoPurge((Handle)glob);
SetComponentInstanceStorage(self, (Handle)glob);

saveZone = GetZone();
inAppHeap = ( GetComponentInstanceA5(self) != 0 );
if ( !inAppHeap )
    SetZone(SystemZone());
if ( (sGlob=(SharedGlobals*)GetComponentRefcon((Component)self)) == nil ) (
    if ( (sGlob = (SharedGlobals*)NewPtrClear(sizeof(SharedGlobals))) == nil )
        result=MemoryError();
        goto obail;
    )
    SetComponentRefcon((Component)self, (long)sGlob);

(*glob)->sharedGlob = sGlob;    // keep this around where it's easy to get at

if ( sGlob->info == nil || *(Handle)sGlob->info == nil ) (
    result=KLOpenInfoRes(self, &(Handle)(sGlob->info));
    HNoPurge((Handle)sGlob->info);
)

obail:
SetZone(saveZone);
if ( result != noErr && sGlob != nil ) (
    if ( sGlob->info )
        DisposHandle((Handle)sGlob->info);
    DisposPtr((Ptr)sGlob);
    SetComponentRefcon((Component)self, (long)nil);
)
(*glob)->size=0;
DebugMsg("\pOpen Codec - end");
return(result);
}

pascal ComponentResult
KLCloseCodec(Handle storage, ComponentInstance self)
{
    SharedGlobals  *sGlob;
    Globals        **glob = (Globals **)storage;

    DebugMsg("\pClose Codec - begin");
    HLock(storage);
    if ( glob ) (
        KLFree(glob);
        KLGetTab(glob, None);
        if (CountComponentInstances((Component)self) == 1) (
            if ( (sGlob=(SharedGlobals*)((*glob)->sharedGlob) != nil ) (
                if ( sGlob->info )
                    HPurge((Handle)sGlob->info);
            )
        )
        DisposHandle((Handle)glob);
    )
}

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

    height = 128;
}
if (!time)
    *time = (width * height * 12);

if (*spatialQuality && *spatialQuality==codecLosslessQuality)
    *spatialQuality = codecMaxQuality;

if (*temporalQuality && *temporalQuality==codecLosslessQuality)
    *temporalQuality = codecMaxQuality;

return(noErr);
}

/*
 * Extends dimensions to make a multiples of 32x16
 */

#define KLExtendWidth(dim) 31-(dim-1&31)
#define KLExtendHeight(dim) 15-(dim-1&15)

pascal ComponentResult
KLGetMaxCompressionSize(Handle storage, PixMapHandle src, const Rect *srcRect, short
    CodecQ quality, long *size)
{
    *pragma unused(storage,src,depth,quality);
    short width = srcRect->right - srcRect->left;
    short height = srcRect->bottom - srcRect->top;

    /* test by just doing RGB storage */

    *size = 3 * (width+KLExtendWidth(width)) * (height+KLExtendHeight(height));
    return(noErr);
}

pascal ComponentResult
KLGetCompressedImageSize(Handle storage, ImageDescriptionHandle desc, Ptr data, long
    DataProcRecordPtr dataProc, long *size)
{
    *pragma unused(storage, dataSize, dataProc, desc)
    short frmh_size;
    long data_size;

    if (size == nil) {
        return(paramErr);
    }
    frmh_size=((KlicsHeader *)data)->description_length;
    data_size=((KlicsFrameHeader *)data)->length;
    *size=(long)frmh_size+data_size;
    return(noErr);
}

void KLSSetup(Boolean still, short width, short height, CodecQ space, CodecQ tem
{
    kle->seqh.head.description_length=sizeof(KlicsSeqHeader);
    kle->seqh.head.version_number(0)=0;
    kle->seqh.head.version_number(1)=1;
    kle->seqh.sequence_size(0)=width;
    kle->seqh.sequence_size(1)=height;
    kle->seqh.sequence_size(2)=0;
    kle->seqh.sub_sample(0)=1;
    kle->seqh.sub_sample(1)=1;
    kle->seqh.wavelet=WT_Daub4;

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

kle->seqh.precision=10;
kle->seqh.octaves[0]=3;
kle->seqh.octaves[1]=2;

kle->frmh.head.description_length=sizeof(KlicsFrameHeader);
kle->frmh.head.version_number[0]=0;
kle->frmh.head.version_number[1]=1;

kle->encd.bpf_in=(2133+temp*160)/8; /* High = 64000 bits/frame, Poor = 1
kle->encd.bpf_out=kle->encd.bpf_in;
kle->encd.buf_size=kle->encd.bpf_in*4;

kle->encd.quant=16-(space*15)/1023;
kle->encd.thresh=1.0;
kle->encd.compare=1.0;
kle->encd.base[0]=0.10;
kle->encd.base[1]=0.10;
kle->encd.base[2]=0.20;
kle->encd.base[3]=0.50;
kle->encd.base[4]=1.00;
kle->encd.intra=still;
kle->encd.auto_q=true;
kle->encd.buf_sw=true;
kle->encd.prevquact=1;
kle->encd.prevbytes=13;
}

#ifdef DECODER
pascal ComponentResult
KLPreCompress(Handle storage,register CodecCompressParams *p)
{
    ComponentResult result;
    CodecCapabilities *capabilities = p->capabilities;
    short width=(p->imageDescription)->width*(capabilities->extendW
    short height=(p->imageDescription)->height*(capabilities->exten
    Globals **glob=(Globals **)storage;
    KlicsE kle=&(*glob)->kle;
    Handle ext=NewHandle(sizeof(KlicsSeqHeader));

    DebugMsg("\pKLPreCompress");
    HLock(storage);
    if (MemError()!=noErr) return(MemError());
    switch ( (p->imageDescription)->depth ) {
        case 24:
            capabilities->wantedPixelSize = 32;
            kle->seqh.channels=3;
            if (noErr!=(result=KLGetTab(glob,UseF32)))
                return(result);
            break;
        default:
            return(codecConditionErr);
            break;
    }

    /* Going to use 3 octaves for Y and 2 for UV so the image must be a multiple o
    capabilities->bandMin = height;
    capabilities->bandInc = capabilities->bandMin;

    capabilities->flags=codecCanCopyPrevComp|codecCanCopyPrev;

    (*glob)->scale[0]=0;
    (*glob)->scale[1]=0;

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

(*glob)->scale[2]=0;

if (noErr!=(result=KLAlloc(glob.height,width,0))) return result;
KLSetup(p->sequenceID==0,width,height,(*p->imageDescription)->spatialQuality,(
BlockMove((Ptr)&kle->seqh,"ext",sizeof(KlicsSeqHeader));
if (noErr!=(result=SetImageDescriptionExtension(p->imageDescription,"ext",klicsC
return result;

HUnlock(storage);
DebugMsg("\pKLPreCompress success");
return(result);
)
#endif

#ifdef ENCODER
pascal long
KLPreDecompress(Handle storage,register CodecDecompressParams *p)
(
ComponentResult result;
CodecCapabilities *capabilities = p->capabilities;
Rect dRect = p->srcRect;
long width;
long height;
long channels;
Glibals **glob=(Globals **)storage;
KlicsZ kle;
Handle ext;
OSErr err;

DebugMsg("\pKLPreDecompress");
if ( ! TransformRect(p->matrix,&dRect,nil) )
return(codecConditionErr);

HLock(storage);
kle=&(*glob)->kle;
switch ( (*p->imageDescription)->depth ) (
case 24:
switch(p->dstPixMap.pixelSize) (
case 32:
capabilities->wantedPixelSize = 32;
if (p->conditionFlags&codecConditionNewDepth) {
if (noErr!=(err=KLGetTab(glob,Use32)))
return(err);
}
break;
case 16:
capabilities->wantedPixelSize = 16;
if (p->conditionFlags&codecConditionNewDepth) {
if (noErr!=(err=KLGetTab(glob,Use16)))
return(err);
}
break;
case 8:
capabilities->wantedPixelSize = 8;
if (p->conditionFlags&codecConditionNewClut) {
if (noErr!=(err=KLGetTab(glob,Use8)))
return(err);
}
break;
}
channels=3;
break;

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

        default:
            return(codecConditionErr);
            break;
    }

    if (noErr!=(result=GetImageDescriptionExtension(p->imageDescription,&ext,klics,
        blockMove(&ext,(Ptr)&kle->seqh,sizeof(KlicsSeqHeader));
        if (channels==1) kle->seqh.channels=1;

    /* Going to use 3 octaves for Y and 2 for UV so the image must be a multiple o

#ifdef HQ
    (*glob)->scale[0]=0; /* Tree scale */
#else
    (*glob)->scale[0]=1; /* Tree scale */
#endif
    width=kle->seqh.sequence_size[0];
    height=kle->seqh.sequence_size[1];

    switch((*glob)->scale[0]) {
    case 1: /* Quarter size internal */
        (*glob)->scale[1]=1;
        if (p->matrix->matrix[0][0]==p->matrix->matrix[1][1])
            switch(p->matrix->matrix[0][0]) {
            case 32768:
                capabilities->flags=codecCanScale;
                capabilities->extendWidth=width/2-dRect.right;
                capabilities->extendHeight=height/2-dRect.bottom;
                (*glob)->scale[2]=1;
                break;
            case 65536:
                capabilities->extendWidth=width-dRect.right;
                capabilities->extendHeight=height-dRect.bottom;
                (*glob)->scale[2]=0;
                break;
            default:
                capabilities->extendWidth=0;
                capabilities->extendHeight=0;
                (*glob)->scale[2]=0;
                break;
            }
        else {
            capabilities->extendWidth=0;
            capabilities->extendHeight=0;
            (*glob)->scale[2]=0;
        }
        break;
    case 0: /* Full size internal */
        if (p->matrix->matrix[0][0]==p->matrix->matrix[1][1])
            switch(p->matrix->matrix[0][0]) {
            case 32768:
                capabilities->flags=codecCanScale;
                capabilities->extendWidth=width/2-dRect.right;
                capabilities->extendHeight=height/2-dRect.bottom;
                (*glob)->scale[1]=1;
                (*glob)->scale[2]=1;
                break;
            case 131072:
                capabilities->flags=codecCanScale;
                capabilities->extendWidth=width*2-dRect.right;
                capabilities->extendHeight=height*2-dRect.bottom;
                (*glob)->scale[1]=0;
                (*glob)->scale[2]=-1;
            }
        else {
            capabilities->extendWidth=0;
            capabilities->extendHeight=0;
            (*glob)->scale[2]=0;
        }
        break;
    }
}

```

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Engineering:KlicsCode:CompFact:KlicsCodec.c

```

        break;
    case 65536:
        capabilities->extendWidth=width-dRect.right;
        capabilities->extendHeight=height-dRect.bottom;
        (*glob)->scale[1]=0;
        (*glob)->scale[2]=0;
        break;
    default:
        capabilities->extendWidth=0;
        capabilities->extendHeight=0;
        (*glob)->scale[1]=0;
        (*glob)->scale[2]=0;
    }
    else {
        capabilities->extendWidth=0;
        capabilities->extendHeight=0;
        (*glob)->scale[1]=0;
        (*glob)->scale[2]=0;
    }
    break;
}

capabilities->bandMin = height;
capabilities->bandInc = capabilities->bandMin;
capabilities->flags|=codecCanCopyPrev|codecCanCopyPrevComp|codecCanRemapColor;

if (noErr!=(result=KLMalloc(glob,height,width,capabilities->wantedPixelSize)))

HUnlock(storage);
DebugMsg("\pKLPreDecompress success");
return(result);
}
#endif

/* Test Versions in C - Colour.c */
void RGB2YUV32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid
void YUV2RGB32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid
void YUV2RGB32x2(Ptr table,long *pixmap, short *Yc, short *Uc, short *Vc, int a

/* Assembler versions - Colour.a */
OUT32X2(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,l
OUT32X2D(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,
OUT32(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
OUT32D(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lo
OUT8X2(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lo
OUT8(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,long
OUT16X2(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,l
OUT16(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
IN32(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,long

/* Assembler versions - Color2.a */
void RGB2YUV2(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int widt
void YUV2RGB2(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int widt
void YUV2RGB3(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int widt
void GREY2Y(long *pixmap, short *Yc, int area, int width, int cols);
void Y2GREY(long *pixmap, short *Yc, int lines, int width, int cols);
void Y2GGG(long *pixmap, short *Yc, int lines, int width, int cols);

/*YUV2RGB4((*glob)->Table,pixmap,src[0],src[1],src[2],cols*(*desc)->height>>scale,
YUV2RGB5((*glob)->Table,pixmap,src[0],src[1],src[2],cols*(*desc)->height,width>>sc

#pragma parameter __D0 MicroSeconds

```



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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

pascal unsigned long MicroSeconds(void) = (0x4EB0, 0x81E1, 0x64C);

unsigned long GetTimerValue(unsigned long *TimerRes)
{
    *TimerRes = CLOCKS_PER_SEC;
    return(MicroSeconds());
}

#ifdef DECODER
pascal long
KLBandCompress(Handle storage, register CodecCompressParams *p)
{
    #pragma unused(storage)
    Globals **glob = (Globals **)storage;
    ImageDescription **desc = p->imageDescription;
    char *baseAddr;
    short rowBytes;
    Rect sRect;
    long offsetH, offsetV;
    OSErr result = noErr;
    short *src[3], *dst[3];
    long *pixmap;
    int width = (*desc)->width + KLExtendWidth((*desc)->width);
    int height = (*desc)->height + KLExtendHeight((*desc)->height);
    int hwidth = width >> 1, hheight = height >> 1;
    int bytes;
    KlicsE kle;
    char mmuMode = 1;
    char intra[] = "\pENC:Intra-mode", inter[] = "\pENC:Inter-mode";
    SharedGlobals *sGlob;

#ifdef PERFORMANCE
    (void)PerfControl(ThePGlobals, true);
#endif

    DebugMsg("\pBandCompress");
    HLock((Handle)glob);
    kle = &(*glob)->kle;
    sGlob = (*glob)->sharedGlob;

    rowBytes = p->srcPixmap.rowBytes & 0x3fff;
    sRect = p->srcPixmap.bounds;
    switch (p->srcPixmap.pixelSize) {
    case 32:
        offsetH = sRect.left << 2;
        break;
    case 16:
        offsetH = sRect.left << 1;
        break;
    case 8:
        offsetH = sRect.left;
        break;
    default:
        result = codecErr;
        DebugMsg("\pError");
        goto bail;
    }
    offsetV = sRect.top * rowBytes;
    baseAddr = p->srcPixmap.baseAddr + offsetH + offsetV;
    pixmap = (long *)baseAddr;

    /* F5MakerSSpec(0.0, "\pUser:crap001", &fsspec);
    F5pCreate(&fsspec, "????", "????", -1);

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

FSOpenDF(&fsspec, fswPerm, &fileRefNum);
area=height*rowBytes;
FSWrite(fileRefNum, &area, (long*)pixmap);
FSClose(fileRefNum);*/

src[0]=(*glob)->src[0]; src[1]=(*glob)->src[1]; src[2]=(*glob)->src[2];
dst[0]=(*glob)->dst[0]; dst[1]=(*glob)->dst[1]; dst[2]=(*glob)->dst[2];
switch(kle->seqn.channels) {
case 3:
    IN32(sClob->tab(User32-1).pixmap.src[0], src[1], src[2], width, height, rowByte
    break;
}

/*.....
 * Klics encode
 *.....*/
#ifdef DEBUG
    if (p->callerFlags&codecFlagUseImageBuffer) DebugStr("\pUseImageBuffer"); /*
    if (p->callerFlags&codecFlagUseScreenBuffer) DebugStr("\pUseScreenBuffer"); /*
    if (p->callerFlags&codecFlagUpdatePrevious) DebugStr("\pUpdatePrevious"); /*
    if (p->callerFlags&codecFlagNoScreenUpdate) DebugStr("\pNoScreenUpdate"); /*
    if (p->callerFlags&codecFlagDontOffscreen) DebugStr("\pDontOffscreen"); /*
    if (p->callerFlags&codecFlagUpdatePreviousComp) DebugStr("\pUpdatePreviousComp
    if (p->callerFlags&codecFlagForceKeyFrame) DebugStr("\pForceKeyFrame"); /*
    if (p->callerFlags&codecFlagOnlyScreenUpdate) DebugStr("\pOnlyScreenUpdate");
#endif

    kle->buf.buf=(unsigned long *) (p->data+sizeof(KlicsFrameHeader));
    kle->encl.intra=(p->temporalQuality==0);
    kle->frmh.frame_number=p->frameNumber;

    bytes=KlicsEncode(src, dst, kle);

    BlockMove((Ptr)&kle->frmh, p->data, sizeof(KlicsFrameHeader));
    bytes+=sizeof(KlicsFrameHeader);

    (*glob)->prev_frame=p->frameNumber;

    p->data+=bytes;
    p->bufferSize=bytes;
    (*p->imageDescription)->dataSize=bytes;

    p->similarity=(kle->encl.intra?0:Long2Fix(244));
    p->callerFlags=0;
/* p->callerFlags|=codecFlagUsedImageBuffer|(kle->encl.intra?codecFlagUsedNewImag
bail:

    MUnlock((Handle)glob);
#ifdef PERFORMANCE
    if (0!=(result=PerfDump(ThePGlobals, "\pEncode.perf", false, 0)))
        return(result);
#endif
    DebugMsg("\pBandCompress success");
    return(result);
}
#endif
/* Display stuff for debugging
CGrafPtr wPort, savePort;

```

- 699 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

Rect      rect;
Str255    str;

GetPort((GrafPtr *)&savePort);
GetCWMgrPort(&wPort);
SetPort((GrafPtr)wPort);
SetRect(&rect, 0, 0, 50, 30);
ClipRect(&rect);
EraseRect(&rect);
NumToString(frmh->frame_number, str);
MoveTo(0, 20);
DrawString(str);
if (frmh->flags & KFH_INTRA) {
    SetRect(&rect, 0, 30, 50, 65);
    ClipRect(&rect);
    EraseRect(&rect);
    NumToString(frmh->frame_number/24, str);
    MoveTo(0, 50);
    DrawString(str);
}
SetRect(&rect, -2000, 0, 2000, 2000);
ClipRect(&rect);
SetPort((GrafPtr)savePort); */

#define flag_tree    0x1
#define flag_wave    0x2
#define flag_show    0x4
#define flag_full    0x8
#define DURATION     65666

long  ModeSwitch(Globals *glob, KlicsFrameHeader *frmh)
{
    long  mode=0, i, fps;
    Boolean repeat=glob->prev_frame==frmh->frame_number,
           next=glob->prev_frame+1==frmh->frame_number;
    CGrafPtr wPort, savePort;
    Rect      rect;
    Str255    str;

    DebugMsg("\pModeSwitch - begin");
    if (frmh->frame_number==0)
        for(i=0; i<15; i++) glob->out[i]=false;
    if (repeat) {
        glob->run_time=0;
        DebugMsg("\pModeSwitch - repeat (end)");
        return(flag_show|flag_full);
    }

    if (next)
        switch(frmh->flags) {
            case KFH_SKIP:
                DebugMsg("\pModeSwitch - next/skip");
                glob->prev_frame=frmh->frame_number;
                if (glob->sys_time>DURATION) {
                    glob->run_time=0;
                    if (glob->real_frame!=glob->dpy_frame)
                        mode|=flag_wave|flag_show;
                } else {
                    unsigned long frame, late;

                    frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
                    late=(glob->sync_time-glob->run_time)%DURATION;
                    if (frame==glob->prev_frame && glob->real_frame!=glob->dpy_frame)

```

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Engineering:KlicsCode:CompFict:KlicsCodec.c

```

    model=flag_wave|flag_show;
/*    if (frame<=glob->prev_frame && late+glob->wave_time+glob->jpy_time
        model=flag_wave|flag_show;*/
    }
    break;
case KFH_INTRA:
    DebugMsg("\pModeSwitch - next/intra");
    mode=flag_tree;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    if (glob->sys_time>DURATION) {
        glob->run_time=0;
        model=flag_wave|flag_show|flag_full;
    } else
/*    if (glob->run_time==0) {*/
        glob->key_time=glob->sync_time-glob->run_time;
        glob->run_time=glob->sync_time-glob->sys_time;
        glob->run_frame=glob->prev_frame;
        model=flag_wave|flag_show|flag_full;
/*    } else {
        unsigned long frame, late;

        frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
        late=(glob->sync_time-glob->run_time)%DURATION;
        if (frame<=glob->prev_frame)
            model=flag_wave|flag_show|flag_full;
    }*/
    break;
default:
    DebugMsg("\pModeSwitch - next/inter");
    mode=flag_tree;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    if (glob->sys_time>DURATION) {
        glob->run_time=0;
        model=flag_wave|flag_show;
    } else
/*    if (glob->run_time==0) {
        glob->run_time=glob->sync_time-glob->sys_time;
        glob->run_frame=glob->prev_frame;
        model=flag_wave|flag_show;
    } else {
        unsigned long frame, late;

        frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
        late=(glob->sync_time-glob->run_time)%DURATION;
        if (frame<=glob->prev_frame)
            model=flag_wave|flag_show;
/*    if (frame<=glob->prev_frame && late+glob->tree_time+glob->wave
        model=flag_wave|flag_show;*/
    }
    break;
}
else
    swicth(frmh->flags) {
case KFH_SKIP:
    DebugMsg("\pModeSwitch - jump/skip");
    glob->run_time=0;
    break;
case KFH_INTRA:
    DebugMsg("\pModeSwitch - jump/intra");
    mode=flag_tree|flag_wave|flag_show|flag_full;
    for(i=glob->prev_frame;i<frmh->frame_number;i++)

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

    > glob->out[frmh->frame_number%15]=0;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    glob->run_time=0;
    break;
default:
    DebugMsg('\pModeSwitch - jump/inter');
    glob->run_time=0;
    break;
)
    DebugMsg('\pModeSwitch - display info');
#ifdef COMPONENT
/* glob->out[frmh->frame_number%15]=(mode&flag_show)!=0;
   for(i=0,fps=0;i<15;i++) if (glob->out[i]) fps++;
   GetPort((GrafPtr *)&savePort);
   GetCWMgrPort(&wPort);
   SetPort((GrafPtr)wPort);
   SetRect(&rect,0,20,120,50);
   ClipRect(&rect);
   EraseRect(&rect);
   NumToString(frmh->frame_number,str);
   MoveTo(0,35);
   DrawString(str);
   DrawString('\p:');
   NumToString(fps,str);
   DrawString(str);
   MoveTo(0,50);
   for(i=0;i<15;i++)
       if (glob->out[i]) DrawString('\pX');
       else DrawString('\pO');
   SetRect(&rect,-2000,0,2000,2000);
   ClipRect(&rect);
   SetPort((GrafPtr)savePort);*/
#endif
    DebugMsg('\pModeSwitch - end');
    return(mode);
}

#ifdef ENCODER
pascal long
KLBandDecompress(Handle storage,register CodecDecompressParams *p)
{
#pragma unused(storage)
    Globals **glob = (Globals **)storage;
    ImageDescription **desc = p->imageDescription;
    int x,y;
    char *baseAddr;
    short rowBytes;
    Rect dRect;
    long offsetH,offsetV;
    OSErr result = noErr;
    short *src[3],*dst[3];
    long *pixmap;
    int width=(*desc)->width+KLExtendWidth((*desc)->width);
    int height=(*desc)->height+KLExtendHeight((*desc)->height);
    int bwidth=width>>1,hheight=height>>1,area=height*width;
    int Klics2 klc;
    KlicsFrameHeader *frmh;
    char mmuMode=1;
    long mode;
    SharedGlobals *sGlob;
/*
    FILE *fp;

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

char          file_name[30];
CGrafPtr      wPort, savePort;
Rect          rect;
Str255        str;
//

HLock((Handle)glob);
DebugMsg("\pBandDecompress");
(!glob)->sys_time=GetTimerValue(&(!glob)->sys_time);
(!glob)->sys_time-=(!glob)->sync_time;

#ifdef PERFORMANCE
(void)PerfControl(ThePGlobals,true);
#endif

kle=(&glob)->kle;
sGlob=(&glob)->sharedGlob;

dRect = p->srcRect;
if ( !TransformRect(p->matrix,&dRect,nil) ) {
    DebugMsg("\pTransformRect Error");
    return(paramErr);
}
rowBytes = p->dstPixMap.rowBytes & 0x3fff;
offsetH = (dRect.left - p->dstPixMap.bounds.left);
switch ( p->dstPixMap.pixelSize ) {
case 32:
    offsetH <<=2;
    break;
case 16:
    offsetH <<=1;
    break;
case 8:
    break;
default:
    result = codecErr;
    DebugMsg("\pDepth Error");
    goto bail;
}
offsetV = (dRect.top - p->dstPixMap.bounds.top) * rowBytes;
baseAddr = p->dstPixMap.baseAddr + offsetH + offsetV;
pixmap=(long *)baseAddr;

/.....
*
*   Klics decode
*
*...../

src[0]=(&glob)->src[0]; src[1]=(&glob)->src[1]; src[2]=(&glob)->src[2];
dst[0]=(&glob)->dst[0]; dst[1]=(&glob)->dst[1]; dst[2]=(&glob)->dst[2];

frmh=(KlicsFrameHeader *)p->data;
kle->buf.buf=(unsigned long *) (p->data+sizeof(KlicsFrameHeader));
mode=ModeSwitch(&glob,frmh);

KlicsDecode(src,dst,&kle->seqh,frmh,&kle->buf,mode,(&glob)->scale,&(&glob)->cr

if ( kle->buf.ptr-kle->buf.buf > frmh->length+2)
    DebugMsg("\pWarning: Decompressor read passed end of buffer");

p->data[0]='X';
p->data[1]=mode&flag_tree?'T': ' ';

```

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Engineering:KlcsCode:CompPict:KlcsCodec.c

```

p->data[2]=mode&flag_wave?'W': ' ';
p->data[3]=mode&flag_show?'S': ' ';
p->data[4]=mode&flag_full?'F': ' ';
p->data[5]=frmh->flags&KFH_INTRA?'I': ' ';
p->data[6]=frmh->flags&KFH_SKIP?'K': ' ';
p->data[7]='X';

p->data+=p->bufferSize;

/.....
.
. signed 10 bit YUV-unsigned 8 RGB convert
.
...../

#ifdef COMPONENT
SwapMMUMode(&mmuMode);
#endif
if (mode&flag_show) {
    (*glob)->sync_time=GetTimerValue(&(*glob)->sync_time);
    (*glob)->dpy_frame=(*glob)->real_frame;
    if ((*glob)->scale[2]<(*glob)->scale[1]) {
        switch(kle->seqh.channels) {
            case 3:
                switch (p->dstPixmap.pixelSize) {
                    case 32:
                        if (mode&flag_full)
                            OUT32X2(sGlob->tab[Use32-1].pixmap,src[0],src[1],src[2],wi.
                        else
                            OUT32X2D(sGlob->tab[Use32-1].pixmap,src[0],src[1],src[2],w
                        break;
                    case 16:
                        OUT16X2(sGlob->tab[Use16-1].pixmap,src[0],src[1],src[2],width>
                        break;
                    case 8:
                        OUT8X2(sGlob->tab[Use8-1].pixmap,src[0],src[1],src[2],width>>
                        break;
                }
                break;
            }
        } else {
            switch(kle->seqh.channels) {
                case 3:
                    switch (p->dstPixmap.pixelSize) {
                        case 32:
                            if (mode&flag_full)
                                OUT32(sGlob->tab[Use32-1].pixmap,src[0],src[1],src[2],width
                            else
                                OUT32D(sGlob->tab[Use32-1].pixmap,src[0],src[1],src[2],wid
                            break;
                        case 16:
                            OUT16(sGlob->tab[Use16-1].pixmap,src[0],src[1],src[2],width>>
                            break;
                        case 8:
                            OUT8(sGlob->tab[Use8-1].pixmap,src[0],src[1],src[2],width>>(*g
                            break;
                    }
                    break;
                }
            }
        }
    }
    (*glob)->dpy_time=GetTimerValue(&(*glob)->dpy_time);
    (*glob)->dpy_time-=(*glob)->sync_time;
}

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```
CLEARA2();
/*glob->sync_time=GetTimerValue(a->glob->sync_time);

#ifdef COMPONENT
    SwapMMUMode(&mmuMode);
#endif

fail:
    HUnlock(Handle(glob));

#ifdef PERFORMANCE
    if(0!=(result=PerfDump(ThePGlobals, "\pDecode.perf", false, 0)))
        return(result);
#endif
    DebugMsg("\pBandDecompress success");
    return(result);
}
#endif
```



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Engineering:KlicsCode:CompPict:Klics.h

```

/.....
.
.  © Copyright 1993 KLICS Limited
.  All rights reserved.
.
.  Written by: Adrian Lewis
.
...../
/*
.  Second generation header file
*/

#include    <stdio.h>

/* useful X definitions */
/*typedef char Boolean;*/
typedef char String;
#define True    1
#define False   0

/* new Blk definition */
typedef int    Blk[4];

#define WT_Haar  0
#define WT_Daub4 1

/* mode constructors */
#define M_LPF    1
#define M_STILL  2
#define M_SEND   4
#define M_STOP   8
#define M_VOID   16
#define M_QUIT   32

/* LookAhead histogram */
#define HISTO    300
#define HISTO_DELTA 15.0
#define HISTO_BITS 10

/* Fast Functions */

/* Is the block all zero ? */
#define BlkZero(block) \
    block[0]==0 && block[1]==0 && block[2]==0 && block[3]==0

/* Sum of the absolute values */
#define Decide(new) \
    abs(new[0]) + \
    abs(new[1]) + \
    abs(new[2]) + \
    abs(new[3])

/* Sum of the absolute differences */
#define DecideDelta(new,old) \
    abs(new[0]-old[0]) + \
    abs(new[1]-old[1]) + \
    abs(new[2]-old[2]) + \
    abs(new[3]-old[3])

/* Adjust the norm for comparison with SigmaAbs */
#define DecideDouble(norm) (4.0*norm)

/* Get addresses from x,y coords of block, sub-band, octave,

```

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Engineering:KlacsCode:Comopict:Klacs.h

```

/* image size and mask (directly related to octave) information */
#define GetAddr(addr,x,y,sub,oct,size,mask) \
{ int smask=mask>>1; \
  x0=x!(sub&1?smask:0); \
  x1=x!(sub&1?smask:0)+mask; \
  y0=y!(sub&2?smask:0)*size[0]; \
  y1=y!(sub&2?smask:0)+mask*size[0]; \
  addr[0]=x0-y0; \
  addr[1]=x1-y0; \
  addr[2]=x0+y1; \
  addr[3]=x1+y1; \
}

/* Get data values from addresses and memory */
#define GetData(addr,block,data) \
{ block[0]=(int)data[addr[0]]; \
  block[1]=(int)data[addr[1]]; \
  block[2]=(int)data[addr[2]]; \
  block[3]=(int)data[addr[3]]; \
}

#define VerifyData(block,mask,tmp) \
{ tmp=block&mask; \
  if (tmp!=0 && tmp!=mask) { \
    block=block<0?mask:-mask; \
  } \
}

/* Put data values to memory using addresses */
#define PutData(addr,block,data) \
{ data[addr[0]]=(short)block[0]; \
  data[addr[1]]=(short)block[1]; \
  data[addr[2]]=(short)block[2]; \
  data[addr[3]]=(short)block[3]; \
}

/* Put zero's to memory using addresses */
#define PutZero(addr,data) \
{ data[addr[0]]=0; \
  data[addr[1]]=0; \
  data[addr[2]]=0; \
  data[addr[3]]=0; \
}

/* Mode: M_VOID Put zero's and find new mode */
#define DoZero(addr,dst,mode,oct) \
{ PutZero(addr,dst); \
  mode[oct]=oct==0?M_STOP:M_VOID; \
}

/* Descend the tree structure
 * Copy mode, decrement octave (& mask), set branch to zero
 */
#define DownCounters(mode,oct,mask,blk) \
{ mode[oct-1]=mode[oct]; \
  oct--; \
  mask = mask>>1; \
  blk[oct]=0; \
}

/* Ascend the tree structure
 * Ascend tree (if possible) until branch not 3
 * If at top then set mode to M_QUIT
 * Else increment branch and x, y coords
 */
#define StopCounters(mode,oct,mask,blk,x,y,octs) \
{ while(oct<octs-1 && blk[oct]!=3) { \

```

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Engineering:KlicsCode:CompPict:Klics.h

```

    blk(oct)=0; \
    mask= mask<<1; \
    x ^= -mask; \
    y ^= -mask; \
    oct++; \
} \
if (oct==octs-1) mode(oct)=M_QUIT; \
else { \
    blk(oct)++; \
    x ^= mask<<1; \
    if (blk(oct)==2) y ^= mask<<1; \
    mode(oct)=mode(oct+1); \
}

```

Engineering:KlitsCode:CompPict:Haar.a

```

-----
.
.  © Copyright 1993 KLICS Limited
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.
.  Written by: Adrian Lewis
.
-----
.
.  68000 FastForward/Backward Haar
.
-----
.
.  macro
.  Fwd0      &addr0,&dG,&dH
.
.  move.w    (&addr0),&dG      ; dG=(short *)&addr1
.  move.w    &dG,&dH            ; dH=dG
.
.  endm
.
-----
.
.  macro
.  Fwd1      &addr1,&addr0,&dG,&dH
.
.  move.w    (&addr1),d0        ; v=(short *)&addr2
.  add.w     d0,&dH              ; dH=v
.  sub.w     d0,&dG              ; dG=v
.  clr.w     d0                 ; d0=0
.  asr.w     #1,&dH              ; dH>>=1
.  addx.w    d0,&dH              ; round dH
.  asr.w     #1,&dG              ; dG>>=1
.  addx.w    d0,&dG              ; round dG
.  move.w    &dH,(&addr0)        ; *(short *)&addr0=dH
.  move.w    &dG,(&addr1)        ; *(short *)&addr1=dG
.
.  mnd
.
-----
.
.  macro
.  Fwd      &base,&end,&inc
.
.  movea.l   &base,a0           ; addr0=base
.  move.l    &inc,d0             ; d0=inc
.  asr.l     #1,d0              ; d0=inc>>1
.  movea.l   a0,a1              ; addr1=addr0
.  suba.l    d0,a1              ; addr1=(inc>>1)
.  @do      Fwd0 a0,d4,d5        ; Fwd0(addr0,dG,dH)
.  adda.l    &inc,a1            ; addr1=inc
.  Fwd1      a1,a0,d4,d5        ; Fwd1(addr1,addr0,dG,dH)
.  adda.l    &inc,a0            ; addr0=inc
.  cmpa.l    a0,&end            ; addr0<end
.  bgt.s     @do               ; while
.
.  endm
.
-----
HaarForward FUNC      EXPORT
.
.  link      a6,#0              ; no local variables
.  movea.l    d4-d7/a3-a5,-(a7) ; store registers
.
.  move.l     $000C(a6),d3       ; inc=inc1
.  movea.l     $0008(a6),a5      ; base=data
.  move.l     $0010(a6),d6       ; end1
.  move.l     $0018(a6),d7       ; end2
.  move.l     $0014(a6),d2       ; inc2

```

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Engineering:KlicsCode:CompPict:Haer.a

```

0do    movea.l    a5,a4          ; end=base
      adda.l     d6,a4          ; end--endl
      Fwd       a5,a4,d3        ; Fwd(base,end,inc)
      adda.l     d2,a5          ; base--inc2
      cmpa.l     d7,a5          ; end2>base
      blt.s      0do           ; for

      movem.l    (a7)+,d4-d7/a3-a5 ; restore registers
      unlk       a6            ; remove locals
      rts        ; return

      ENDFUNC
-----
      macro
      Bwd0       &addr0,&dG,&dH

      move.w     (&addr0),&dG    ; dG=(short *)addr0
      move.w     &dG,&dH         ; dH=dG

      endm
-----
      macro
      Bwd1       &addr1,&addr0,&dG,&dH

      move.w     (&addr1),d0     ; v=(short *)addr1
      add.w      d0,&dH          ; dH+=v
      sub.w      d0,&dG          ; dG-=v
      move.w     &dH,(&addr0)    ; *(short *)addr0=dH
      move.w     &dG,(&addr1)    ; *(short *)addr1=dG

      endm
-----
      macro
      Bwd        &base,&count,&inc

      movea.l    &base,a0        ; addr0=base
      move.l     &inc,d0         ; d0=inc
      asr.l      #1,d0           ; d0=inc>>1
      movea.l    a0,a1          ; addr1=addr0
      suba.l     d0,a1           ; addr1-=inc>>1
0do    Bwd0      a0,d4,d5        ; Bwd0(addr0,dG,dH)
      adda.l     &inc,a1         ; addr1+=inc
      Bwd1      a1,a0,d4,d5     ; Bwd1(addr1,addr0,dG,dH)
      adda.l     &inc,a0         ; addr0+=inc
      dbf        &count,0do     ; while --count
      endm
-----
HaarBackward    FUNC    EXPORT
*   d0 - spare, d1 - count1, d2 - inc2, d3 - incl, d4 - dG, d5 - dH, d6 - loop1, d
*
      link       a6,#0          ; no local variables
      movem.l    d4-d7/a3-a5,-(a7) ; store registers

      move.l     $000C(a6),d3    ; inc=incl
      movea.l    $0008(a6),a5    ; base=data
      move.l     $0010(a6),d6    ; loop1 (width/height)
      move.l     $0018(a6),d7    ; loop2 (height/width)
      move.l     $0014(a6),d2    ; inc2
      subq.l     #1,d7           ; loop2-=1
      lsr.l      #1,d6           ; loop1/=2
      subq.l     #1,d6           ; loop1-=1

```

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Engineering:KlincsCode:CompPict:Haar.a

```

edo    move.l    d6,d1      : count1=loop1
        bwd      a5,d1,d3    : bwd(base.count.inc)
        adda.l    d2,a5      : base+=inc2
        dbf      d7,edo      : while -1!--loop2
.
        movem.l    (a7)-,d4-d7/a3-a5 : restore registers
        unlk      a6         : remove locals
        rts         : return

```

ENDFUNC

```

-----
HaarXTopBwd FUNC      EXPORT
.
        link      a6,#0      : no local variables
.
        movea.l    S0008(a6),a0 : start
        move.l     S000C(a6),d3 : area
        lsr.l      #1,d3      : area (long)
        subq.l     #1,d3      : area-=1
edo     move.l     (a0),d0      : d0=HG*Y
        move.l     d0,d1      : d1=HG
        swap       d1         : d1=GH
        neg.w      d0         : d0=H(-G)
        add.l      d1,d0      : d0=01
        move.l     d0,(a0)+   : *Y++=a01
        dbf      d3,edo      : while -1!--area
.
        unlk      a6         : remove locals
        rts         : return

```

ENDFUNC

```

-----
HaarTopBwd FUNC      EXPORT
.
        link      a6,#0      : no local variables
        movem.l    d4-d6,-(a7) : store registers
.
        movea.l    S0008(a6),a0 : startH
        movea.l    a0,a1      : startG
        move.l     S000C(a6),d4 : height
        move.l     S0010(a6),d3 : width
        move.l     d3,d6      : linenlen=width
        add.l      d6,d6      : linenlen (bytes)
        lsr.l      #1,d4      : height/=2
        lsr.l      #1,d3      : width/=2
        subq.l     #1,d4      : height-=1
        subq.l     #1,d3      : width-=1
edo1     adda.l     d6,a1      : startG+=linelen
        move.l     d3,d5      : linecount=width
edo2     move.l     (a0),d0      : d0=HAHB*Y0
        move.l     (a1),d1      : d1=GAGB*Y1
        move.l     d0,d2      : d2=HAHB
        add.l      d1,d0      : d0=0A0B
        sub.l      d1,d2      : d2=1A1B
.
        move.l     d0,d1      : d1=HG
        swap       d1         : d1=GH
        neg.w      d0         : d0=H(-G)
        add.l      d1,d0      : d0=01
        move.l     d0,(a0)+   : *Y0++=0A0B
.
        move.l     d2,d1      : d1=HG
        swap       d1         : d1=GH

```



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Engineering:KlidsCode:CompPict:ConvolveSH3.c

```

.....
*
* Copyright 1993 KLICS Limited
* All rights reserved.
*
* Written by: Adrian Lewis
*
...../
..
2D wavelet transform convolver (fast hardware emulation)
New improved wavelet coeffs : 11 19 5 3

Optimized for speed:
    dirm = false
    src/dst octave == 0
*/

#define FwdS1(addr0,dAG,dAH) \
    v=(short *)addr0; \
    dAG=(v)+v*(vs<<1); \
    dAG+=v*(vs<<1); \
    dAH=v3+(vs<<1); \
    dAH+=v3*(vs<<1);

#define Fwd1(addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBG=(v)+v*(vs<<1); \
    dAH+=v*(vs<<1); \
    dBH=v3+(vs<<1); \
    dAG+=v3*(vs<<1);

#define Fwd2(addr2,addr1,addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dAH+=(v)+v*(vs<<1); \
    dBG+=v*(vs<<1); \
    dAG+=v3*(vs<<1); \
    dBH+=v3*(vs<<1); \
    *(short *)addr0=(dAH+15)>>5; \
    *(short *)addr1=(dAG+15)>>5;

#define Fwd3(addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAG=(v)+v*(vs<<1); \
    dBH+=v*(vs<<1); \
    dAH+=v3*(vs<<1); \
    dBG+=v3*(vs<<1);

#define Fwd0(addr0,addr3,addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dBH+=(v)+v*(vs<<1); \
    dAG+=v*(vs<<1); \
    dBG+=v3*(vs<<1); \
    dAH+=v3*(vs<<1); \
    *(short *)addr2=(dBH+15)>>5; \
    *(short *)addr3=(dBG+15)>>5;

#define FwdE(addr3,addr2,dBG,dBH) \
    v=(short *)addr3; \
    dBH+=(vs<<1); \
    dBG+=(vs<<2); \
    *(short *)addr2=(dBH+15)>>5; \
    *(short *)addr3=(dBG+15)>>5;

```



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Engineering:KlicsCode:CompFict:ConvolvesH3.c

```

#define Fwd(base, end, inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    FwdS(addr0, dAG, dAH); \
    addr1+=inc; \
    Fwd1(addr1, dAG, dAH, dBG, dBH); \
    addr2+=inc; \
    Fwd2(addr2, addr1, addr0, dAG, dAH, dBG, dBH); \
    addr3+=inc; \
    while(addr3<end) { \
        Fwd3(addr3, dAG, dAH, dBG, dBH); \
        addr0+=inc; \
        Fwd0(addr0, addr3, addr2, dAG, dAH, dBG, dBH); \
        addr1+=inc; \
        Fwd1(addr1, dAG, dAH, dBG, dBH); \
        addr2+=inc; \
        Fwd2(addr2, addr1, addr0, dAG, dAH, dBG, dBH); \
        addr3+=inc; \
    } \
    FwdE(addr3, addr2, dBG, dBH);

extern void FASTFORWARD(char *data, long incl, long end1, long inc2, char *end2);
extern void HAARFORWARD(char *data, long incl, long end1, long inc2, char *end2);

void FastForward(char *data, long incl, long end1, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, dBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data; base<end2; base+=inc2) {
        end=base+end1;
        Fwd(base, end, inc);
    }
}

void Daub4Forward(short *data, int size[2], int oct_dst)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=0; oct!=oct_dst; oct++) {
        long cinc=2<<oct, cinc4=cinc<<2,
            rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t.

        FASTFORWARD((char *)data, cinc4, width-cinc, rinc, top);
        FASTFORWARD((char *)data, rinc4, area-rinc, cinc, left);
    }
}

void HaarForward(short *data, int size[2], int oct_dst)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=0; oct!=oct_dst; oct++) {
        long cinc=2<<oct, cinc2=cinc<<1,

```

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Engineering:K1:csCode:CompPict:ConvolveSH3.c

```

rinc=size[0]<<oct+1, rinc2=rinc<<1; /* col and row increments in c
HAARFORWARD((char *)data,cinc2,width,rinc,top);
HAARFORWARD((char *)data,rinc2,area,cinc,left);
}

void Hybr.dForward(short *data, int size[2], int oct_dst)
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    HAARFORWARD((char *)data,4,width,size[0]<<1,top);
    HAARFORWARD((char *)data,size[0]<<2,area,2,left);
    for(oct=1;oct!=oct_dst;oct++) {
        long   cinc=2<<oct, cinc4=cinc<<2,
                rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in c

        FASTFORWARD((char *)data,cinc4,width-cinc,rinc,top);
        FASTFORWARD((char *)data,rinc4,area-rinc,cinc,left);
    }
}

#define BwdS0(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG=-(v3=v+(vs=v<<1)); \
    dAH=v+(vs<<1); \
    dBH=vs<<1; \

#define BwdS1(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH=(vs=v<<1); \
    v3=vs+v; \
    dAG+=v3-(vs<<2); \
    dAH+=v3-(vs<<1); \
    *(short *)addr0=(dBH+3)>>3;

#define Bwd2(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG=-(v3=v+(vs=v<<1)); \
    dBH=v+(vs<<1); \
    dAH+=v3-(vs<<1); \
    dAG+=v3-(vs<<1);

#define Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH=(v3=v+(vs=v<<1)); \
    dAG+=v+(vs<<1); \
    dBG+=v3-(vs<<1); \
    dBH=v3-(vs<<1); \
    *(short *)addr1=(dAH+7)>>4; \
    *(short *)addr2=(dAG+7)>>4;

#define Bwd0(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG=-(v3=v+(vs=v<<1)); \
    dAH=v+(vs<<1); \
    dBH+=v3-(vs<<1); \
    dBG+=v3-(vs<<1);

#define Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \

```

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Engineering:KlissCode:CompPict:ConvolveSH3.c

```

    dBH+=v3+v*(vs<=1); \
    DBG+=v*(vs<=1); \
    DAG+=v3+v*(vs<=1); \
    dAH+=v3+v*(vs<=1); \
    *(short *)addr3=(dBH+7)>>4; \
    *(short *)addr0=(DBG+7)>>4;

#define BwdE2(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    v3=v*(vs<=1); \
    dBH=(vs<=2); \
    dAH+=v3+v; \
    DAG+=v3+v*(vs<=1);

#define BwdE3(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+=v3+v*(vs<=1); \
    DAG+=v*(vs<=1); \
    dBH+=v3+v*(vs<=1); \
    dBH+=v3+v*(vs<=1); \
    *(short *)addr1=(dAH+7)>>4; \
    *(short *)addr2=(DAG+7)>>4; \
    *(short *)addr3=(dBH+3)>>3;

#define Bwd(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0(addr0,dAG,dAH,dBH); \
    addr1+=inc; \
    BwdS1(addr1,addr0,dAG,dAH,dBH); \
    addr2+=inc; \
    while(addr2<end) { \
        Bwd2(addr2,dAG,dAH,dBG,dBH); \
        addr3+=inc; \
        Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
        addr0+=inc; \
        Bwd0(addr0,dAG,dAH,dBG,dBH); \
        addr1+=inc; \
        Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
        addr2+=inc; \
    } \
    BwdE2(addr2,dAG,dAH,dBH); \
    addr3+=inc; \
    BwdE3(addr3,addr2,addr1,dAG,dAH,dBH);

extern void FASTBACKWARD(char *data, long incl, long loop1, long inc2, char *end2)
extern void HAARBACKWARD(char *data, long incl, long loop1, long inc2, long loop2)
extern void HAARTOPBWD(char *data, long height, long width);
/* extern void HAARXTOPBWD(char *data, long area); */

void FastBackward(char *data, long incl, long end1, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, DBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data;base<end2;base+=inc2) {
        end=base+end1;
        Bwd(base,end,inc);
    }
}

```

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Engineering:KlicsCode:CompPict:ConvolveSH3.c

```

)

void Daub4Backward(short *data, int size[2], int oct_src)
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1; oct>=0; oct--) {
        long  cinc=2<<oct, cinc4=cinc<<2,
              rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in c

        FASTBACKWARD((char *)data, rinc4, area-(rinc<<1), cinc, left);
        FASTBACKWARD((char *)data, cinc4, width-(cinc<<1), rinc, top);
    }

void HaarBackward(data, size, oct_src)

short  *data;
int     size[2], oct_src;

{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1; oct>=0; oct--) {
        long  cinc=2<<oct, cinc2=cinc<<1,
              rinc=size[0]<<oct+1, rinc2=rinc<<1; /* col and row increments in c

        HAARBACKWARD((char *)data, rinc2, size[1]>>oct, cinc, size[0]>>oct);
        HAARBACKWARD((char *)data, cinc2, size[0]>>oct, rinc, size[1]>>oct);
    }
    HAARTOPBWD((char *)data, size[1], size[0]);
    /* HAARXTOPBWD((char *)data, area>>1); */
}

void HybridBackward(data, size, oct_src)

short  *data;
int     size[2], oct_src;

{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1; oct>=0; oct--) {
        long  cinc=2<<oct, cinc4=cinc<<2,
              rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in c

        FASTBACKWARD((char *)data, rinc4, area-(rinc<<1), cinc, left);
        FASTBACKWARD((char *)data, cinc4, width-(cinc<<1), rinc, top);
    }
    HAARTOPBWD((char *)data, size[1], size[0]);
    /* HAARXTOPBWD((char *)data, area>>1); */
}

```

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Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

-----
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
-----
*
*   68000 FastForward/Backward code
*
-----
        seg            'klics'

        macro
FwdStart      &addr0,&dAG,&dAH

        move.w        (&addr0),d0      ; vs=(short *)addr0
        move.w        d0,d1            ; vs=v
        add.w         d1,d1            ; vs<<=1
        move.w        d1,d2            ; v}=vs
        add.w         d0,d2            ; v}=vs+v
        move.w        d2,&dAG          ; dAG=v}
        add.w         d1,d1            ; vs<<=1
        add.w         d0,&dAG          ; dAG+=v
        add.w         d1,&dAG          ; dAG+=vs
        move.w        d2,&dAH          ; dAH=v}
        add.w         d1,d1            ; vs<<=1
        add.w         d1,&dAH          ; dAH+=vs
        add.w         d2,&dAH          ; dAH+=v}
        add.w         d1,d1            ; vs<<=1
        add.w         d1,&dAH          ; dAH+=vs

        endm

        macro
FwdOdd        &addr1,&dAG,&dAH,&DBG,&DBH

        move.w        (&addr1),d0      ; vs=(short *)addr1
        move.w        d0,d1            ; vs=v
        add.w         d1,d1            ; vs<<=1
        move.w        d1,d2            ; v}=vs
        add.w         d0,d2            ; v}=vs+v
        move.w        d2,&DBG          ; DBG=v}
        add.w         d1,d1            ; vs<<=1
        add.w         d0,&dAH          ; dAH+=v
        add.w         d1,&dAH          ; dAH+=vs
        move.w        d2,&DBH          ; DBH=v}
        add.w         d1,d1            ; vs<<=1
        add.w         d1,&DBH          ; DBH+=vs
        sub.w         d2,&dAG          ; dAG-=v}
        add.w         d1,d1            ; vs<<=1
        sub.w         d1,&dAG          ; dAG-=vs

        endm

        macro
FwdEven       &addr2,&addr1,&addr0,&dAG,&dAH,&DBG,&DBH

        move.w        (&addr2),d0      ; vs=(short *)addr2
        move.w        d0,d1            ; vs=v
        add.w         d1,d1            ; vs<<=1
        move.w        d1,d2            ; v}=vs

```

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Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

add.w    d0,d2      ; v3=vs+v
sub.w    d2,&dAH     ; dAH-=v3
add.w    d1,d1      ; vs<<=1
add.w    d0,&DBG     ; DBG+=v
add.w    d1,&DBG     ; DBG+=vs
add.w    d2,&dAG     ; dAG+=v3
add.w    d1,d1      ; vs<<=1
add.w    d1,&dAG     ; dAG+=vs
add.w    d2,&dBH     ; dBH+=v3
add.w    d1,d1      ; vs<<=1
add.w    d1,&dBH     ; dBH+=vs
clr.w    d0         ; d0=0
asr.w    #5,&dAH     ; dAH>>=5
addx.w   d0,&dAH     ; round dAH
asr.w    #5,&dAG     ; dAG>>=5
addx.w   d0,&dAG     ; round dAG
move.w   &dAH,(&addr0) ; *(short *)addr0=dAH
move.w   &dAG,(&addr1) ; *(short *)addr1=dAG

```

mend

```

macro
FwdEnd    &addr3,&addr2,&DBG,&dBH

```

```

move.w   (&addr3),d0 ; v=*(short *)addr3
add.w    d0,d0       ; v<<=1
add.w    d0,&dBH     ; dBH+=v
lsl.w    #2,d0       ; v<<=2
sub.w    d0,&DBG     ; DBG-=v
clr.w    d0         ; d0=0
asr.w    #5,&dBH     ; dBH>>=5
addx.w   d0,&dBH     ; round dBH
asr.w    #5,&DBG     ; DBG>>=5
addx.w   d0,&DBG     ; round DBG
move.w   &dBH,(&addr2) ; *(short *)addr2=dBH
move.w   &DBG,(&addr3) ; *(short *)addr3=DBG

```

endm.

```

macro
Fwd        &base,&end,&inc

```

```

movea.l   &base,a0      ; addr0=base
move.l    &inc,d0       ; d0=inc
asr.l     #2,d0         ; d0=inc>>2
movea.l   a0,a3         ; addr3=addr0
suba.l    d0,a3         ; addr3-=inc>>2
movea.l   a3,a2         ; addr2=addr3
suba.l    d0,a2         ; addr2-=inc>>2
movea.l   a2,a1         ; addr1=addr2
suba.l    d0,a1         ; addr1-=inc>>2
FwdStart  a0,d4,d5      ; FwdStart(addr0,dAG,dAH)
adda.l    &inc,a1       ; addr1+=inc
FwdOdd    a1,d4,d5,d6,d7 ; FwdOdd(addr1,dAG,dAH,dBG,dBH)
adda.l    &inc,a2       ; addr2+=inc
FwdEven   a2,a1,a0,d4,d5,d6,d7 ; FwdEven(addr2,addr1,addr0,dAG,dAH,dB
adda.l    &inc,a3       ; addr3+=inc
FwdOdd    a3,d6,d7,d4,d5 ; FwdOdd(addr3,dBG,dBH,dAG,dAH)
adda.l    &inc,a0       ; addr0+=inc
FwdEven   a0,a3,a2,d6,d7,d4,d5 ; FwdEven(addr0,addr3,addr2,dBG,dBH,dA
adda.l    &inc,a1       ; addr1+=inc
FwdOdd    a1,d4,d5,d6,d7 ; FwdOdd(addr1,dAG,dAH,dBG,dBH)
adda.l    &inc,a2       ; addr2+=inc

```

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Engineering:K1:csCode:CompPict:ConvoiveSH3.a

```

FwdEven      a2,a1,a0,d4,d5,d6,d7      ; FwdEven(addr2,addr1,addr0,dAG,dAH,dB
adda.l       &inc,a3                    ; addr3+=inc
cmpa.l       a3,&end                    ; addr3<end
bgr.w        @do                        ; while
FwdEnd       a3,a2,d6,d7                ; FwdEnd(addr3,addr2,dBG,dBH)

endm

-----
FastForward FUNC      EXPORT
link          a6,#0                     ; no local variables
movem.l       d4-d7/a3-a5,-(a7)         ; store registers

move.l        $000C(a6),d3              ; inc=inc1
movea.l       $0008(a6),a5              ; base=data
@do           movea.l       a5,a4        ; end=base
adda.l        $0010(a6),a4              ; end+=end1
Fwd           a5,a4,d3                  ; Fwd(base,end,inc)
adda.l        $0014(a6),a5              ; base+=inc2
cmpa.l        $0018(a6),a5              ; end2>base
blt.w         @do                       ; for

movem.l       (a7)+,d4-d7/a3-a5         ; restore registers
unlk          a6                        ; remove locals
rts           ; return

ENDFUNC

-----
macro
BwdStart0      &addr0,&dAG,&dAH,&dBH

move.w        (&addr0),d0              ; v=(short *)addr0
move.w        d0,d1                    ; vs=v
add.w         d1,d1                     ; vs<<=1 (vs=2v)
add.w         d1,d0                     ; v+=vs (v=3v)
move.w        d0,&dAG                   ; dAG=v3
neg.w         &dAG                       ; dAG=-dAG
move.w        d0,&dAH                     ; dAH=v
add.w         d1,&dAH                     ; dAH+=vs
lsl.w         #2,d1                     ; vs<<=2 (vs=8v)
move.w        d1,&dBH                     ; dBH=vs

endm

-----
macro
BwdStart1      &addr1,&addr0,&dAG,&dAH,&dBH

move.w        (&addr1),d0              ; v=(short *)addr1
move.w        d0,d1                     ; vs=v
add.w         d1,d1                     ; vs<<=1
add.w         d1,&dBH                     ; dBH+=vs
add.w         d1,d0                     ; v+=vs (v=3v)
lsl.l         #2,d1                     ; vs<<=2 (vs=8v)
add.w         d1,d0                     ; v+=vs (v=11v)
add.w         d0,&dAG                     ; dAG+=v
add.w         d1,d0                     ; v+=vs (v=19v)
sub.w         d0,&dAH                     ; dAH-=v
clr.w         d0                         ; d0=0
asr.w         #3,&dBH                     ; dBH>>=3
addx.w        d0,&dBH                     ; round dBH
move.w        &dBH,(&addr0)              ; *(short *)addr0=dBH

endm

```

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Engineering:KlacsCode:CompPict:ConvolveSH3.a

```

-----
macro
BwdEven &addr2,&dAG,&dAH,&DBG,&DBH

move.w    (&addr2).d0    : v=*(short *)&addr2
move.w    d0,d1          : vs=v
add.w     d1,d1          : vs<<=1 (vs=2v)
add.w     d1,d0          : v+=vs (v=3v)
move.w    d0,&DBG        : DBG=v
neg.w     &DBG            : DBG=-DBG
move.w    d0,&DBH        : DBH=v
add.w     d1,&DBH        : DBH+=vs
lsl.w     #2,d1          : vs<<=2 (vs=8v)
add.w     d1,d0          : v+=vs (v=11v)
add.w     d0,&dAH        : dAH+=v
add.w     d1,d0          : v+=vs (v=19v)
add.w     d0,&dAG        : dAG+=v

endm

```

```

-----
macro
BwdOdd &addr3,&addr2,&addr1,&dAG,&dAH,&DBG,&DBH

move.w    (&addr3).d0    : v=*(short *)&addr3
move.w    d0,d1          : vs=v
add.w     d1,d1          : vs<<=1 (vs=2v)
add.w     d1,d0          : v+=vs (v=3v)
add.w     d0,&dAH        : dAH+=v
add.w     d0,&dAG        : dAG+=v
add.w     d1,&dAG        : dAG+=vs
lsl.w     #2,d1          : vs<<=2 (vs=8v)
add.w     d1,d0          : v+=vs (v=11v)
add.w     d0,&DBG        : DBG+=v
add.w     d1,d0          : v+=vs (v=19v)
sub.w     d0,&DBH        : DBH-=v
clr.w     d0             : d0=0
asr.w     #4,&dAH        : dAH>>=4
addx.w    d0,&dAH        : round dAH
move.w    &dAH,(&addr1)   : *(short *)&addr1=dAH
asr.w     #4,&dAG        : dAG>>=4
addx.w    d0,&dAG        : round dAG
move.w    &dAG,(&addr2)   : *(short *)&addr2=dAG

endm

```

```

-----
macro
BwdEnd2 &addr2,&dAG,&dAH,&DBH

move.w    (&addr2).d0    : v=*(short *)&addr2
move.w    d0,d1          : vs=v
add.w     d1,d1          : vs<<=1 (vs=2v)
add.w     d1,d0          : v+=vs (v=3v)
lsl.w     #2,d1          : vs<<=2 (vs=8v)
move.w    d1,&DBH        : DBH=vs
add.w     d1,d0          : v+=vs (v=11v)
add.w     d0,&dAH        : dAH+=v
add.w     d1,d0          : v+=vs (v=19v)
add.w     d0,&dAG        : dAG+=v

endm

```

```

-----
macro
BwdEnd? &addr3,&addr2,&addr1,&dAG,&dAH,&DBH

```



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Engineering:KilcsCode:CompPict:ConvolveSH3.a

```

move.w    (&addr3).d0      ; v=(short *)addr3
move.w    d0,d1            ; v=v
add.w     d1,d1            ; v<=<=1 (v=2v)
add.w     d1,d0            ; v+=v (v=3v)
add.w     d0,&dAH          ; dAH+=v
add.w     d0,&dAG          ; dAG+=v
add.w     d1,&dAG          ; dAG+=v
add.w     d1,&dBH          ; dBH+=v
lsl.l     #4,d1            ; v<=<=4 (v=32v)
sub.w     d1,&dBH          ; dBH-=v
clr.w     d0               ; d0=0
asr.w     #4,&dAH          ; dAH>>=4
addx.w    d0,&dAH          ; round dAH
move.w    &dAH,(&addr1)    ; *(short *)addr1=dAH
asr.w     #4,&dAG          ; dAG>>=4
addx.w    d0,&dAG          ; round dAG
move.w    &dAG,(&addr2)    ; *(short *)addr2=dAG
asr.w     #3,&dBH          ; dBH>>=3
addx.w    d0,&dBH          ; round dBH
move.w    &dBH,(&addr3)    ; *(short *)addr3=dBH

endm

-----
macro      Bwd              &base,&end,&inc
movea.l    &base,a0
move.l     &inc,d0          ; addr0=base
asr.l      #2,d0            ; d0=inc
movea.l    a0,a3            ; d0=inc>>2
suba.l     d0,a3            ; addr3=addr0
movea.l    a3,a2            ; addr3-=(inc>>2)
suba.l     d0,a2            ; addr2=addr3
movea.l    a2,a1            ; addr2-=(inc>>2)
suba.l     d0,a1            ; addr1=addr2
BwdStart0  a0,d4,d5,d7      ; addr1-=(inc>>2)
adda.l     &inc,a1          ; BwdStart0(addr0,dAG,dAH,dBH)
BwdStart1  a1,a0,d4,d5,d7   ; addr1+=inc
adda.l     &inc,a2          ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
BwdEven    a2,d4,d5,d6,d7   ; addr2+=inc
adda.l     &inc,a3          ; BwdEven(addr2,dAG,dAH,dBG,dBH)
BwdOdd     a3,a2,a1,d4,d5,d6,d7 ; addr3+=inc
adda.l     &inc,a0          ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
BwdEven    a0,d6,d7,d4,d5   ; addr0+=inc
adda.l     &inc,a1          ; BwdEven(addr0,dBG,dBH,dAG,dAH)
BwdOdd     a1,a0,a3,d6,d7,d4,d5 ; addr1+=inc
adda.l     &inc,a2          ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
cmpa.l     a2,&end          ; addr2+=inc
bgt        @do              ; addr2<end
BwdEnd2    a2,d4,d5,d7      ; while
adda.l     &inc,a3          ; BwdEnd2(addr2,dAG,dAH,dBH)
BwdEnd3    a3,a2,a1,d4,d5,d7 ; addr3+=inc
                                ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB)

endm

-----
FastBackward      FUNC      EXPORT
link              a6,#0      ; no local variables
movea.l           d4-d7/a3-a5,-(a7) ; store registers
move.l            S000C(a6),d3 ; inc=incl
movea.l           S000B(a6),a5 ; base=data

```

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Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

ndo      movea.l    a5,a4                : end=base
         adda.l     $0010(a6),a4         : end+=end1
         bwd        a5,a4,d3             : Bwd(base,end,inc)
         adda.l     $0014(a6),a5         : base+=inc2
         cmpa.l     $0018(a6),a5         : end2>base
         blt.w      Gdo                  : for
.
         movem.l    (a7)+,d4-d7/a3-a5    : restore registers
         unlink     a6                   : remove locals
         rts                          : return
.
ENDFUNC
-----
END

```

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Engineering:KlicsCode:CompPict:Colour.c

```

.....
.
.  © Copyright 1993 KLICS Limited
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.
.  Written by: Adrian Lewis
.
...../
/*
.  Test versions of colour space conversions in C
*/

#include <Memory.h>
#include <QuickDraw.h>

#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr=(type)NewPtr(size))) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr=(type)NewPtr(size))) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

typedef union {
    long    pixel;
    char    rgb[4];
} Pixel;

/* Special YUV space version */
#define rgb_yuv(pixmap,Yc) \
    pixel.pixel=0x808080~*pixmap++; \
    r=(short)pixel.rgb[1]; \
    g=(short)pixel.rgb[2]; g+=g; \
    b=(short)pixel.rgb[3]; \
    Y=(b<<3)-b; \
    g+=r; \
    Y+=g-g-g; \
    Y>>=4; \
    Y+=g; \
    *Yc++=Y; \
    Y>>=2; \
    U=b-Y; \
    V=r-Y;

#define limit(Y,low,high) \
    Y<(low<<2)?low<<2:Y>(high<<2)?high<<2:Y

/* Standard YUV space version - Bt294 CR07(0) mode limiting */
#define rgb_yuv32(pixmap,Yc) \
    pixel.pixel=0x808080~*pixmap++; \
    r=(long)pixel.rgb[1]; \
    g=(long)pixel.rgb[2]; \
    b=(long)pixel.rgb[3]; \
    Y= (306*r + 601*g + 117*b)>>8; \
    *Yc++ = limit(Y,16-128,235-128); \
    U= (512*r - 429*g - 83*b)>>8; \
    V= (-173*r - 339*g + 512*b)>>8;

void    RGB2YUV32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid

```

Engineering:KilcsCode:CompPict:Colcur.c

```

long    *pixmap2=pixmap*cols, *row, *end=pixmap-area;
short   *Yc2=Yc*width;

while(pixmap<end) {
    row=pixmap+width;
    while(pixmap<row) {
        Pixel pixel;
        long   r,g,b,Y,U=0,V=0;

        rgb_yuv32(pixmap,Yc);
        rgb_yuv32(pixmap,Yc);
        rgb_yuv32(pixmap2,Yc2);
        rgb_yuv32(pixmap2,Yc2);
        U>>=2;
        V>>=2;
        *Uc++=limit(U,16-128,240-128);
        *Vc++=limit(V,16-128,240-128);
    }
    pixmap+=cols*cols-width;
    pixmap2+=cols*cols-width;
    Yc+=width;
    Yc2+=width;
}

typedef struct {
    short  ry, rv, by, bu;
} RGB_Tab;

OSErr RGBTable(long **tab)
{
    RGB_Tab *table;
    int      i;
    THz      saveZone;

    NewPointer(table,RGB_Tab*,256*sizeof(RGB_Tab));
    *tab=(long *)table;
    for(i=0;i<128;i++) {
        table[i].ry=306*i>>8;
        table[i].rv=173*i>>8;
        table[i].by=117*i>>8;
        table[i].bu=83*i>>8;
    }
    for(i=128;i<256;i++) {
        table[i].ry=306*(i-256)>>8;
        table[i].rv=173*(i-256)>>8;
        table[i].by=117*(i-256)>>8;
        table[i].bu=83*(i-256)>>8;
    }
    return(noErr);
}

typedef struct {
    short  ru, gu, bv, gv;
} UV32_Tab;

UV32_Tab *UV32_Table()
{
    UV32_Tab *table;
    int      i;

    table=(UV32_Tab *)NewPtr(256*sizeof(UV32_Tab));

```

Engineering:KillsCode:CompPict:Colour.c

```

    for(i=0;i<128;i++) {
        table(i).ru=128-(1436*i>>10);
        table(i).gu=128-(-731*i>>10);
        table(i).bv=128-(1815*i>>10);
        table(i).gv=-352*i>>10;
    }
    for(i=128;i<256;i++) {
        table(i).ru=128-(1436*(i-256)>>10);
        table(i).gu=128-(-731*(i-256)>>10);
        table(i).bv=128-(1815*(i-256)>>10);
        table(i).gv=-352*(i-256)>>10;
    }
    return(table);
}

typedef struct {
    long    u, v;
} UV32Tab;

OSErr  UV32Table(long **tab)
{
    long    *ytab;
    UV32Tab *uvtab;
    int     i;
    THz     saveZone;

    NewPointer(*tab, long*, 512*sizeof(long)+512*sizeof(UV32Tab));
    ytab=*tab;
    uvtab=(UV32Tab*)&ytab[512];
    for(i=-256;i<256;i++) {
        long    yyy, sp;

        sp=0x000000fe&(i<-128?0:i>127?255:i+128);
        yyy=sp; yyy<<=8;
        yyy|=sp; yyy<<=8;
        yyy|=sp;
        ytab[0x000001ff&i]=yyy;
    }
    for(i=-256;i<256;i++) {
        long    ru,gu,bv,gv;

        ru=0xffffffff&(1436*i>>10);
        gu=0x000001fe&(-731*i>>10);
        bv=0x000001fe&(1815*i>>10);
        gv=0x000001fe&(-352*i>>10);

        uvtab[0x000001ff&i].u=(ru<<8)|gu<<8;
        uvtab[0x000001ff&i].v=(gv<<8)|bv;
    }
    return(noErr);
}

typedef struct {
    short    u, v;
} UV16Tab;

OSErr  UV16Table(long **tab)
{
    short    *ytab;
    UV16Tab *uvtab;
    int     i;
    THz     saveZone;

```

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Engineering:KlucsCode:CompPict:Colour.c

```

NewPointer(*tab,long*.512*sizeof(short)-512*sizeof(UV16Tab));
ytab=(short **)tab;
uvtab=(UV16Tab*)&ytab[512];
for(i=-256;i<256;i++) {
    long    yyy, sp;

    sp=0x0000001e&((i<-129?0:i>127?255:i-128)>>31);
    yyy=sp; yyy<=5;
    yyy|=sp; yyy<=5;
    yyy|=sp;
    ytab[0x000001ff&i]=yyy;
}
for(i=-256;i<256;i++) {
    long    ru,gu,bv,gv;

    ru=0xffffffff&(1436*i>>13);
    gu=0x00000003&(-731*i>>13);
    bv=0x00000003&(1815*i>>13);
    gv=0x00000003&(-352*i>>13);

    uvtab[0x000001ff&i].u=((ru<<5)|gu)<<5;
    uvtab[0x000001ff&i].v=(gv<<5)|bv;
}
return(noErr);
}

#define over(val) \
((0xFF00&(val)) == 0)?(char)val:val<0?0:255

/* Standard YUV space version */
#define yuv_rgb32(pixmap,Yc) \
Y=(*Yc++)>>2; \
pixel.rgb[1]=over(Y-r); \
pixel.rgb[2]=over(Y-g); \
pixel.rgb[3]=over(Y-b); \
*pixmap++=pixel.pixel;

void YUV2RGB32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid)
{
    long    *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short    *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel    pixel;
            long    r,g,b,Y,U,V;

            U=(*Uc++)>>2;
            V=(*Vc++)>>2;
            r=128+(1436*U>>10);
            g=128+(-731*U - 352*V>>10);
            b=128+(1815*V>>10);

            yuv_rgb32(pixmap,Yc);
            yuv_rgb32(pixmap,Yc);
            yuv_rgb32(pixmap2,Yc2);
            yuv_rgb32(pixmap2,Yc2);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
    }
}

```

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Engineering:KlicsCode:CompPict:Colour.c

```

        Yc2+=width;
    )
}

#define rgb32_yuv(pixmap,Yc) \
    pixel.pixel=0x808080~*pixmap++; \
    r=pixel.rgb[1]; \
    g=pixel.rgb[2]; \
    b=pixel.rgb[3]; \
    Y= (table[0xFF&r].ry + (g<<2)-table[0xFF&g].ry-table[0xFF&g].by + table[0xFF&b \
    *Yc++ = limit(Y,16-128,235-128); \
    U= (r<<1) -g -table[0xFF&g].rv - table[0xFF&b].bu; \
    V= (b<<1) -g -table[0xFF&r].rv - table[0xFF&g].bu;

void RGB32YUV( RGB_Tab *table, long *pixmap, short *Yc, short *Uc, short *Vc, int
{
    long *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel pixel;
            long r,g,b,Y,U=0,V=0;

            rgb32_yuv(pixmap,Yc);
            pixel.pixel=0x808080~*pixmap++;
            r=pixel.rgb[1];
            g=pixel.rgb[2];
            b=pixel.rgb[3];
            Y= (table[0xFF&r].ry + (g<<2)-table[0xFF&g].ry-table[0xFF&g].by + tabl
            *Yc++ = limit(Y,16-128,235-128);
            U= (r<<1) -g -table[0xFF&g].rv - table[0xFF&b].bu;
            V= (b<<1) -g -table[0xFF&r].rv - table[0xFF&g].bu;

            rgb32_yuv(pixmap,Yc);
            rgb32_yuv(pixmap2,Yc2);
            rgb32_yuv(pixmap2,Yc2);
            U>>=2;
            V>>=2;
            *Uc++=limit(U,16-128,240-128);
            *Vc++=limit(V,16-128,240-128);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
        Yc2+=width;
    }
}

#define yuv_rgb32x2(pixmap,Y) \
    pixel.rgb[1]=over(Y+r); \
    pixel.rgb[2]=over(Y+g); \
    pixel.rgb[3]=over(Y+b); \
    pixmap[cols]=pixel.pixel; \
    *pixmap++=pixel.pixel;

void YUV2RGB32x2(UV32_Tab *table, long *pixmap, short *Yc, short *Uc, short *Vc,
{
    long *pixmap2=pixmap+2*cols, *row, *end=pixmap+area;
    short *Yc2=Yc+width;

```

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Engineering:Kl:csCode:CompPict:Colour.c

```

while(pixmap<end) {
    long    Ycld=*Yc>>2, Yold2=*Yc2>>2;

    row=pixmap*width*2;
    while(pixmap<row) {
        Pixel    pixel;
        long      z,g,b,Y,U,V;

        U=0x00FF&((*Uc++)>>2);
        V=0x00FF&((*Vc++)>>2);
        r=table[U].ru;
        g=table[U].gu+table[V].gv;
        b=table[V].bv;

        Y=(*Yc++)>>2;
        Yold=(Y+Yold)>>1;
        yuv_rgb32x2(pixmap,Yold);

        Yold=Y;
        yuv_rgb32x2(pixmap,Yold);

        Y=(*Yc++)>>2;
        Yold=(Y+Yold)>>1;
        yuv_rgb32x2(pixmap,Yold);

        Yold=Y;
        yuv_rgb32x2(pixmap,Yold);

        Y=(*Yc2++)>>2;
        Yold2=(Y+Yold2)>>1;
        yuv_rgb32x2(pixmap2,Yold2);

        Yold2=Y;
        yuv_rgb32x2(pixmap2,Yold2);

        Y=(*Yc2++)>>2;
        Yold2=(Y+Yold2)>>1;
        yuv_rgb32x2(pixmap2,Yold2);

        Yold2=Y;
        yuv_rgb32x2(pixmap2,Yold2);
    }
    pixmap+=4*cols-2*width;
    pixmap2+=4*cols-2*width;
    Yc+=width;
    Yc2+=width;
}

#define yuv_rgb8(pixel,Yc,index,dith) \
    Y=*Yc++; \
    Y<<=3; \
    Y&= 0x3F00; \
    Y!= U; \
    pixel.rgb[index]=table[Y].rgb[dith];

void    YUV2RGB8(Pixel *table,long *pixmap, short *Yc, short *Uc, short *Vc, int a
{
    long    *pixmap2=pixmap+cols/1, *row, *end=pixmap+area/4;
    short    *Yc2=Yc+width;

    while(pixmap<end) {

```



Engineering:KlicsCode:CcmpPict:Colour.c

```

row=pixmap+width/4;
while(pixmap<row) {
    Pixel    pixel, pixel2;
    long     Y,U,V;

    U=*Uc++;
    V=*Vc++;
    U>>=2;
    V>>=6;
    U= (U&0xF0) | (V&0x0F);

    yuv_rgb8(pixel,Yc,0,3);
    yuv_rgb8(pixel,Yc,1,0);
    yuv_rgb8(pixel2,Yc2,0,1);
    yuv_rgb8(pixel2,Yc2,1,2);

    U=*Uc++;
    V=*Vc++;
    U>>=2;
    V>>=6;
    U= (U&0xF0) | (V&0x0F);

    yuv_rgb8(pixel,Yc,2,3);
    yuv_rgb8(pixel,Yc,3,0);
    yuv_rgb8(pixel2,Yc2,2,1);
    yuv_rgb8(pixel2,Yc2,3,2);

    *pixmap++=pixel.pixel;
    *pixmap2++=pixel2.pixel;
}
pixmap+=(cols+cols-width)/4;
pixmap2+=(cols+cols-width)/4;
Yc+=width;
Yc2+=width;
}

#define yuv_rgb8x2(pixel,pixel2,Y,index,dith,dith2) \
    YL= 0x3F00; \
    YI= 0; \
    pixel.rgb[index]=table[Y].rgb[dith]; \
    pixel2.rgb[index]=table[Y].rgb[dith2];

void YUV2RGB8x2(Pixel *table,long *pixmap, short *Yc, short *Uc, short *Vc, int
{
    long     *pixmap2=pixmap+cols/2, *row, *end=pixmap+area/4;
    short     *Yc2=Yc+width;

    while(pixmap<end) {
        long     Yold=*Yc<<3, Yold2=*Yc2<<3;

        row=pixmap+width/2;
        while(pixmap<row) {
            Pixel    pixel, pixel2, pixel3, pixel4;
            long     Y,U,V;

            U=*Uc++;
            V=*Vc++;
            U>>=2;
            V>>=6;
            U= (U&0x00F0) | (V&0x000F);

            Y=(*Yc++)<<3;

```

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Engineering:Kl:csCode:CompPict:Colour.c

```

Yold=(Y+Yold)>>1;
yuv_rgb8x2(pixel,pixel2,Y,0,3,1);

Yold=Y;
yuv_rgb8x2(pixel,pixel2,Y,1,0,2);
Yold=Y;

Y=(*Yc++)<<3;
Yold=(Y+Yold)>>1;
yuv_rgb8x2(pixel,pixel2,Y,2,3,1);

Yold=Y;
yuv_rgb8x2(pixel,pixel2,Y,3,0,2);
Yold=Y;

Y=(*Yc2++)<<3;
Yold2=(Y+Yold2)>>1;
yuv_rgb8x2(pixel3,pixel4,Y,0,3,1);

Yold2=Y;
yuv_rgb8x2(pixel3,pixel4,Y,1,0,2);
Yold2=Y;

Y=(*Yc2--)<<3;
Yold2=(Y+Yold2)>>1;
yuv_rgb8x2(pixel3,pixel4,Y,2,3,1);

Yold2=Y;
yuv_rgb8x2(pixel3,pixel4,Y,3,0,2);
Yold2=Y;

pixmap[cols/4]=pixel2.pixel;
*pixmap++=pixel.pixel;

pixmap2[cols/4]=pixel4.pixel;
*pixmap2++=pixel3.pixel;
}
pixmap+=(cols+cols-width)/2;
pixmap2+=(cols+cols-width)/2;
Yc+=width;
Yc2+=width;
}

#define yuv_rgbTEST(pixel,index,Y) \
    rgb_col.reds=(Y+r<<8); \
    rgb_col.green=(Y+g<<8); \
    rgb_col.blue=(Y+b<<8); \
    pixel.rgb[index]=Color2Index(&rgb_col);

void YUV2RGBTEST(UV32_Tab *table,long *pixmap, short *Yc, short *Uc, short *Vc,
{
    long *pixmap2=pixmap+cols/2, *row, *end=pixmap+area/4;
    short *Yc2=Yc+width;

    while(pixmap<end) {
        long Yold=*Yc<<3, Yold2=*Yc2<<3;

        row=pixmap+width/2;
        while(pixmap<row) {
            RGBColor rgb_col;
            Pixel pixel, pixel2;

```

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Engineering:KlicsCode:CompPict:Colour.c

```

long  r,g,b,Y,U,V;

U=0x00FF&((*Uc++)>>2);
V=0x00FF&((*Vc++)>>2);
r=table[U].ru;
g=table[U].gu+table[V].gv;
b=table[V].bv;

Y=(*Yc++)>>2;
Yold=(Y+Yold)>>1;
rgb_col.red=(Yold+r<<8);
rgb_col.green=(Yold+g<<8);
rgb_col.blue=(Yold+b<<8);
pixel.rgb[0]=Color2Index(&rgb_col);

Yold=Y;
yuv_rgbTEST(pixel,1,Yold);

Y=(*Yc++)>>2;
Yold=(Y+Yold)>>1;
yuv_rgbTEST(pixel,2,Yold);

Yold=Y;
yuv_rgbTEST(pixel,3,Yold);

Y=(*Yc2++)>>2;
Yold2=(Y+Yold2)>>1;
yuv_rgbTEST(pixel2,0,Yold2);

Yold2=Y;
yuv_rgbTEST(pixel2,1,Yold2);

Y=(*Yc2++)>>2;
Yold2=(Y+Yold2)>>1;
yuv_rgbTEST(pixel2,2,Yold2);

Yold2=Y;
yuv_rgbTEST(pixel2,3,Yold2);

pixmap[cols/4]=pixel.pixel;
*pixmap++=pixel.pixel;

pixmap2[cols/4]=pixel2.pixel;
*pixmap2++=pixel2.pixel;
)
pixmap+=(cols+cols-width)/2;
pixmap2+=(cols+cols-width)/2;
Yc+=width;
Yc2+=width;
)

```

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Engineering:KlicsCode:CompPict:Colcur.a

```

-----
.
.  © Copyright 1993 KLIcs Limited
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.
.  Written by: Adrian Lewis
.
-----
.
.  68030 Colour space conversions
.
-----
      machine mc68030
      seg      'klics'
      include 'Traps.a'
-----

      macro
      DPY32x2      &ARGB, &row, &o0, &ol, &n0, &n1

      add.l      &n0, &o0
      lsr.l      #1, &o0
      add.l      &n1, &ol
      lsr.l      #1, &ol
      ; interpolate first pixel
      ; interpolate first pixel

      move.l      &o0, (&ARGB)
      add.l      &row, &ARGB
      move.l      &o0, (&ARGB)
      add.l      &row, &ARGB
      move.l      &ol, (&ARGB)
      add.l      &row, &ARGB
      move.l      &ol, (&ARGB)+

      move.l      &n1, (&ARGB)
      sub.l      &row, &ARGB
      move.l      &n1, (&ARGB)
      sub.l      &row, &ARGB
      move.l      &n0, (&ARGB)
      sub.l      &row, &ARGB
      move.l      &n0, (&ARGB)+

      endm

      macro
      DPY32      &ARGB, &row, &o0, &ol, &n0, &n1

      move.l      &o0, (&ARGB)
      add.l      &row, &ARGB
      move.l      &ol, (&ARGB)+

      move.l      &n1, (&ARGB)
      sub.l      &row, &ARGB
      move.l      &n0, (&ARGB)+

      endm

      macro
      UV2RGB32      &AU, &AV, &TAB

      add.l      #2048, &TAB
      ; move to uvtab

      move.w      &AU, d1
      lsr.w      #2, d1
      and.w      #S01FF, d1
      ; Load U

```

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Engineering:KlicsCode:CompPict:Colour.a

```

move.l    (%TAB,d1.w*8),d0      ; UV now rg (u)

move.w    &AV,d1                ; Load V
lsr.w     #2,d1
and.w     #01FF,d1
add.l     4(%TAB,d1.w*8),d0      ; UV now rgb

move.l    d0,d1                  ; 3 copies
move.l    d0,d2
move.l    d0,d3

sub.l     #2048,&TAB             ; restore ytab

endm

-----
macro
GETY32    &AY, &TAB, &RGB0, &RGB1

move.l    &AY,d4                  ; Y
lsr.w     #2,d4
and.w     #01FF,d4
add.l     (%TAB,d4.w*4),&RGB1     ; RGB1+=YYY

swap      d4
lsr.w     #2,d4
and.w     #01FF,d4
add.l     (%TAB,d4.w*4),&RGB0     ; RGB0+=YYY

endm

-----
macro
OVER32    &RGB

move.l    &RGB,d4                ; copy pixel
andi.l    #01010100,d4          ; was it this rgb
beq.s     @nx_rgb                ; if not then quit
btst      #24,d4                 ; R overflow?
beq.s     @bit16                 ; if not then continue
btst      #23,&RGB                ; test sign
beq.s     @pos23                 ; if positive
andi.l    #0000ff,&RGB           ; underflow sets R to 0
bra.s     @bit16                 ; do next bit
@pos23    ori.l    #00ff0000,&RGB ; overflow sets R to 255
@bit16    btst      #16,d4        ; G overflow?
beq.s     @bit8                 ; if not then continue
btst      #15,&RGB                ; test sign
beq.s     @pos16                 ; if positive
andi.w    #00ff,&RGB             ; underflow sets G to 0
bra.s     @bit8                 ; do next bit
@pos16    ori.w    #fff00,&RGB    ; overflow sets G to 255
@bit8     btst      #8,d4         ; B overflow?
beq.s     @end                  ; if not then continue
btst      #7,&RGB                ; test sign
seq       &RGB                  ; under/over flow
@end      andi.l    #00fefefe,&RGB ; mask RGB ok
@nx_rgb

endm

-----
macro
HASHOUT32 &AH, &D0, &D1, &D2, &D3

move.l    &D0,d4

```



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Engineering:KlacsCode:CompPict:Colour.a

```

lsr.l    #1,d1          ; width*height/2
add.l    #1,d1          ; U*width*height/2
move.l   d1,LS.U_ey(a6) ; SAVE U_ey
add.l    d0,d0          ; width*2
move.l   d0,LS.Y1(a6)   ; SAVE Y1
move.l   d0,LS.Y_y(a6)  ; SAVE Y_y
lsr.l    #2,d0          ; width*8
move.l   PS.rowByte(a6),d1 ; LOAD rowBytes
lsr.l    #2,d1          ; rowBytes*4
sub.l    d0,d1          ; rowBytes*4-width*8
move.l   d1,LS.P_y(a6)  ; SAVE P_y

move.l   PS.rowByte(a6),d5 ; load rowBytes
clr.l    d6             ; clear old2
clr.l    d7             ; clear old1

@do_y    move.l   LS.U_ix(a6),d0 ; LOAD U_ixB
add.l    a1,d0          ; P+U_ixB
move.l   d0,LS.U_ex(a6) ; SAVE U_exB

@do_x    UV2RGB32      (a1)+,(a2)+,a4 ; uv2rgb(*U++,*V++)

move.l   LS.Y1(a6),d4    ; load Yrow
GETY32   (a0,d4,1),a4,d2,d3 ; add Yb to RGB values
GETY32   (a0)+,a4,d0,d1  ; add Ya to RGB values

move.l   d0,d4
or.l     d1,d4
or.l     d2,d4
or.l     d3,d4
andi.l   #501010100,d4
bne.s    @over          ; if overflow

@ok      HASHOUT32      (a5)+,d0,d1,d2,d3

DPY32x2  a3,d5,d6,d7,d0,d2
DPY32x2  a3,d5,d0,d2,d1,d3

move.l   d1,d6          ; copy olds
move.l   d3,d7

cmpa.l   LS.U_ex(a6),a1
blt.w    @do_x

add.l    LS.Y_y(a6),a0
add.l    LS.P_y(a6),a3

cmpa.l   LS.U_ey(a6),a1
blt.w    @do_y

movem.l  (a7)+,d4-d7/a3-a5 ; restore registers
unlk     a6              ; remove locals
rts      ; return

@over    OVER32         d0
OVER32   d1
OVER32   d2
OVER32   d3
bra      @ok

```

ENDFUNC

-----  
OUT32X2D    FUNC    EXPORT





- 737 -

Engineering:KlicsCode:CompPict:Colour.a

```

GETY32      (a0)+,a4,d0,d1      ; add Ya to RGB values
           =
           move.l      d0,d4
           or.l        d1,d4
           or.l        d2,d4
           or.l        d3,d4
           andi.l      #501010100,d4
           bne.w       @over      ; if overflow

@ok         HASHCMP32      (a5)+,d0,d1,d2,d3
           bne.s       @diff

           add.l        #16,a3      ; add four pixels

@cont       move.l      d1,d6      ; copy clds
           move.l      d3,d7

           cmpa.l      LS.U_ex(a6),a1
           blt.w       @do_x

           add.l        LS.Y_y(a6),a0
           add.l        LS.P_y(a6),a3

           cmpa.l      LS.U_ey(a6),a1
           blt.w       @do_y

           movem.l     (a7)+,d4-d7/a3-a5      ; restore registers
           unlk        a6                ; remove locals
           rts                ; return

@diff       move.l      d4,-4(a5)
           DPY32x2      a3,d5,d6,d7,d0,d2
           DPY32x2      a3,d5,d0,d2,d1,d3

@over       OVER32      d0
           OVER32      d1
           OVER32      d2
           OVER32      d3
           bra         @ok

           ENDFUNC
-----
OUT32      FUNC      EXPORT
PS         RECORD      8
table      DS.L        1
pixmap     DS.L        1
Y          DS.L        1
U          DS.L        1
V          DS.L        1
width      DS.L        1
height     DS.L        1
rowByte    DS.L        1
p:xmap2    DS.L        1
           ENDR

LS         RECORD      0,DECR
Yl         DS.L        1      ; sizeof(short)*Yrow      = 2*width
U_ex       DS.L        1      ; x end address        = U+U_ix
U_ey       DS.L        1      ; y end address        = U+width*height>>
U_ix       DS.L        1      ; sizeof(short)*U/row  = width
Y_y        DS.L        1      ; sizeof(short)*Yrow   = 2*width
P_y        DS.L        1      ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize      EQU         .

```

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Engineering:KlacsCode:CompPict:Colour.a

```

ENDR      =
.
.
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
.
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - cld0, d7
.

link      a6, #LS.LSize      : inc. width, fend and rowend are loca
movem.l   d4-d7/a3-a5, -(a7) : store registers

move.l    PS.Y(a6), a0       : Y=Yc
move.l    PS.U(a6), a1       : U=Uc
move.l    PS.V(a6), a2       : V=Vc
move.l    PS.pixmap(a6), a3   : pm=pixmap
move.l    PS.table(a6), a4    : tab=table
move.l    PS.pixmap2(a6), a5  : pm2=pixmap2

move.l    PS.width(a6), d0    : LOAD width
move.l    d0, LS.U_ix(a6)     : SAVE U_ix
move.l    PS.height(a6), d1   : LOAD height
mulu.w    d0, d1              : width*height
lsr.l     #1, d1              : width*height/2
add.l     a1, d1              : U=width*height/2
move.l    d1, LS.U_ey(a6)     : SAVE U_ey
add.l     d0, d0              : width*2
move.l    d0, LS.Yl(a6)       : SAVE Yl
move.l    d0, LS.Y_y(a6)      : SAVE Y_y
add.l     d0, d0              : width*4
move.l    PS.rowByte(a6), d1  : LOAD rowBytes
add.l     d1, d1              : rowBytes*2
sub.l     d0, d1              : rowBytes*2-width*4
move.l    d1, LS.P_y(a6)      : SAVE P_y

move.l    PS.rowByte(a6), d5   : load rowBytes
move.l    LS.Yl(a6), d6       : load Yrow

@do_y     move.l    LS.U_ix(a6), d7 : LOAD U_ix3
add.l     a1, d7              : P+U_ix3

@dc_x     UV2RGB32    (a1)+, (a2)+, a4 : uv2rgb(*U++, *V++)

GETY32    (a0, d6, 1), a4, d2, d3 : add Yb to RGB values
GETY32    (a0)+, a4, d0, d1      : add Ya to RGB values

move.l    d0, d4
or.l      d1, d4
or.l      d2, d4
or.l      d3, d4
andi.l    #01010100, d4
bne.s     @over                : if overflow

@ok       HASHOUT32    (a5)+, d0, d1, d2, d3
DPY32     a3, d5, d0, d2, d1, d3

cmpa.l    d7, a1
blt.w     @do_x

add.l     LS.Y_y(a6), a0
add.l     LS.P_y(a6), a3

cmpa.l    LS.U_ey(a6), a1
blt.w     @do_y

movem.l   (a7)+, d4-d7/a3-a5    : restore registers

```



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Engineering:KlicsCode:CompPict:Colour.a

```

        move.l    =>PS.rcwByte(a6).d5      : load rcwBytes
        move.l    LS.Y1(a6).d6             : load Yrow

@do_y    move.l    LS.U_ix(a6).d7          : LOAD U_ixB
        add.l     a1,d7                    : P+U_ixB

@do_x    UV2RGB32    (a1)+,(a2)+,a4        : uv2rgb(*U++,*V++)

        move.l    LS.Y1(a6).d4             : load Yrow
        GETY32    (a0,d6.1),a4,d2,d3      : add Yb to RGB values
        GETY32    (a0)+,a4,d0,d1          : add Ya to RGB values

        move.l    d0,d4
        or.l      d1,d4
        or.l      d2,d4
        or.l      d3,d4
        andi.l    #S01010100,d4
        bne.s     @over                    : if overflow

@ok      HASHCMP32    (a5)+,d0,d1,d2,d3
        bne.s     @diff

        addq       #8,a3                    : add four pixels

@cont:    cmpa.l     d7,a1
        blt.w     @do_x

        add.l      LS.Y_y(a6),a0
        add.l      LS.P_y(a6),a3

        cmpa.l     LS.U_ey(a6),a1
        blt.w     @do_y

        movem.l    (a7)+,d4-d7/a3-a5      : restore registers
        unlink     a6                     : remove locals
        rts                    : return

@diff    move.l     d4,-4(a5)
        DPY32      a3,d5,d0,d2,d1,d3
        bra.s      @cont

@over    OVERJ2     d0
        OVERJ2     d1
        OVERJ2     d2
        OVERJ2     d3
        bra        @ok

        -----
        macro
        UVOV        &VAL, &OV

        move.w      &VAL,&OV
        add.w        #S0200,&OV
        and.w        #SFC00,&OV
        beq.s        @ok
        tst.w        &OV
        bge.s        @pos
        move.w       #S01FF,&VAL
        bra.s        @ok
        move.w       #SFE00,&VAL

        endm

@pos
@ok

```

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Engineering:KlicsCode:CompPict:Colour.a

```

UVLIMIT FUNC      EXPORT
* fix d0, d4, spare d1, d2
    UVOV          d0, d1
    swap          d0
    UVOV          d0, d1
    swap          d0
    UVOV          d4, d1
    swap          d4
    UVOV          d4, d1
    swap          d4
    rts

    ENDFUNC

macro
UVOVER            &U, &V

    move.l        #502000200, d1
    move.l        d1, d2
    add.l         &U, d1
    add.l         &V, d2
    or.l          d2, d1
    andi.l        #SFC00FC00, d1
    beq.s         @UVok
    bsr          UVLIMIT
@UVok

    endm

macro
GETUV            &AU, &AV, &SP, &UV

    move.l        (&AU)+, &SP
    move.l        (&AV)+, &UV
    UVOVER        &SP, &UV
    lsr.l         #5, &UV
    andi.l        #03e003e0, &SP
    andi.l        #001f001f, &UV
    or.l          &SP, &UV          ; UV==500UV'00UV
    swap          &UV

    endm

macro
GETY             &AY, &IND, &UV, &R0, &R1

    move.l        &AY, &R1          ; (2+) Y=Y0Y1
    lsl.l         #5, &R1          ; (4) Y=Y0XXY1XX
    andi.l        #SFC00FC00, &R1
    or.w          &UV, &R1          ; (2) Y=Y1UV
    move.l        (&IND, &R1 .w*4), &R0 ; (2+) R0=0123 (Y1)
    swap          &R1              ; (4) Y=Y0XX
    or.w          &UV, &R1          ; (2) Y=Y0UV
    move.l        (&IND, &R1 .w*4), &R1 ; (2+) R1=0123 (Y0)

    endm

macro
UV8             &AU, &AV, &SP, &UV

    move.l        (&AU)+, &SP
    move.l        (&AV)+, &UV
    UVOVER        &SP, &UV

```

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Engineering:KlucsCode:CompPict:Colour.a

```

lsr.l    >    #2,&SP
lsr.l    #6,&UV
andl.l   #00F000F0,&SP
andl.l   #000F000F,&LV
or.l     &SP,&UV          ; UV==500UV00UV
swap     &UV

endm

macro
Y2IND    &Y,&IND,&UV,&D0,&D1

move.l   &Y,&D0          ; d0=Y0Y1
lsr.l    #3,&D0          ; d0=Y0XXY1XX
move.b   &UV,&D0          ; d0=Y0XXY1UV
andl.w   #03FFF,&D0      ; d0=0YUV(1)
move.l   (&IND,&D0 .w*4),&D1 ; find clut entries
swap     &D0            ; d0=Y0XX
move.b   &UV,&D0          ; d0=Y0UV
andl.w   #03FFF,&D0      ; d0=0YUV(0)
move.l   (&IND,&D0 .w*4),&D0 ; find clut entries

endm

OUT8      FUNC      EXPORT
.
PS        RECORD      8
table     DS.L         1
pixmap    DS.L         1
Y         DS.L         1
U         DS.L         1
V         DS.L         1
width     DS.L         1
height    DS.L         1
rowByte   DS.L         1
pixmap2   DS.L         1
ENDR
.
LS        RECORD      0,DECK
Y1        DS.L         1          ; sizeof(short)*Yrow      = 2*width
U_ex      DS.L         1          ; x end address          = U-U_ix
U_ey      DS.L         1          ; y end address          = U*width+height>>
U_ix      DS.L         1          ; sizeof(short)*Uvrow    = width
Y_y       DS.L         1          ; sizeof(short)*Yrow      = 2*width
P_y       DS.L         1          ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize     EQU          *
ENDR
.
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

link      a6,#LS.LSize          ; inc. width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7)    ; store registers

move.l    PS.Y(a6),a0          ; Y=Yc
move.l    PS.U(a6),a1          ; U=Uc
move.l    PS.V(a6),a2          ; V=Vc
move.l    PS.pixmap(a6),a3     ; pm=pixmap
move.l    PS.table(a6),a4      ; tab=table
adda.l    #00020000,a4         ; tch=32768 (longs)
move.l    PS.pixmap2(a6),a5    ; pm2=pixmap2

move.l    PS.width(a6),d0      ; LOAD width

```

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Engineering: KlicsCode:CompPict:Colour.a

```

move.l    d0,LS.U_ix(a6)           ; SAVE U_ix
move.l    = PS.height(a6),d1       ; LOAD height
mulu.w    d0,d1                    ; width*height
lsr.l     #1,d1                    ; width*height/2
add.l     a1,d1                    ; U*width*height/2
move.l    d1,LS.U_ey(a6)          ; SAVE U_ey
move.l    PS.rowByte(a6),d1       ; LOAD rowBytes
add.l     d1,d1                    ; rowBytes*2
sub.l     d0,d1                    ; rowBytes*2-width
move.l    d1,LS.P_y(a6)           ; SAVE P_y
add.l     d0,d0                    ; width*2
move.l    d0,LS.Y1(a6)            ; SAVE Y1
move.l    d0,LS.Y_y(a6)           ; SAVE Y_y

move.l    PS.rowByte(a6),d5       ; load rowBytes
move.l    LS.Y1(a6),d6            ; load Yrow

@do_y     move.l    LS.U_ix(a6),d7   ; LOAD U_ixB
add.l     a1,d7                   ; P-U_ixB

@do_x     GETUV    a1,a2,d0,d4

GETY      (a0,d6.w),a4,d4,d2,d3    ; d2=X0XX, d3=XX1X
GETY      (a0)+,a4,d4,d0,d1       ; d0=XXX0, d1=1XXX

move.w    d3,d2                   ; d2=X01X
lsr.l     #8,d2                   ; d2=01XX
move.w    d0,d1                   ; d1=1XX0
swap      d1                       ; d1=X01X
lsr.l     #8,d1                   ; d1=01XX

swap      d4                       ; next UV

GETY      (a0,d6.l),a4,d4,d0,d3    ; d0=X2XX, d3=XX1X
move.w    d3,d0                   ; d0=X23X
lsr.l     #8,d0                   ; d0=XX23
move.w    d0,d2                   ; d2=0123-
GETY      (a0)+,a4,d4,d0,d3       ; d0=XXX2, d3=3XXX
move.w    d0,d3                   ; d3=3XX2
swap      d3                       ; d3=X23X
lsr.l     #8,d3                   ; d3=XX23
move.w    d3,d1                   ; d1=C123

move.l    d2,(a3,d5)
move.l    d1,(a3)+

cmpa.l    d7,a1
blt.w     @do_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS.U_ey(a6),a1
blt.w     @do_y

moveem.l  (a7)+,d4-d7/a3-a5        ; restore registers
unlk      a6                       ; remove locals
rts

ENDFUNC
-----
macro
Y8x2      &AY,&IND,&UV,&old

```

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Engineering:KlacsCode:CompPict:Colour.a

```

move.l    &AY,d0                ; (2+) Y=Y0Y1
lsl.l     #3,d0                 ; (4) Y=Y0XXY1XX
swap      d0                    ; (4) Y=Y1XXY0XX
add.w     d0,&old                ; (2) old=old+Y0
lsl.w     #1,&old               ; (4) old=(old+Y0)/2
move.b    &UV,&old              ; (2) old=Y10UV
andi.w    #53FFF,&old           ; (4) old=0YUV(10)
move.l    (&IND,&old.w*4),d1    ; (2+) d1=X1X3
move.w     d0,&old              ; (2) old=Y0
move.b     &UV,d0               ; (2) Y=Y0UV
andi.w    #53FFF,d0            ; (4) Y=0YUV(0)
move.l    (&IND,d0.w*4),d2     ; (2+) d2=0X2X
move.w     d1,d3               ; (2) exg.w d1,d2
move.w     d2,d1               ; (2) d1=X12X
move.w     d3,d2               ; (2) d2=0XX3
swap       d2                  ; (4) d2=X30X
lsl.l     #8,d1                ; (4) d1=12XX
lsl.l     #8,d2                ; (4) d2=30XX
swap       d0                  ; (4) Y=Y1XX
add.w     d0,&old              ; (2) old=old+Y1
lsl.w     #1,&old               ; (4) old=(old+Y1)/2
move.b     &UV,&old            ; (2) old=Y11UV
andi.w     #53FFF,&old         ; (4) old=0YUV(11)
move.l     (&IND,&old.w*4),d3   ; (2+) d3=X1X3
move.w     d0,&old              ; (2) old=Y1
move.b     &UV,d0              ; (2) Y=Y0UV
andi.w     #53FFF,d0           ; (4) Y=0YUV(0)
move.l     (&IND,d0.w*4),d0     ; (2+) d0=0X2X
move.w     d0,d1               ; (2) exg.w d0,d3
move.w     d3,d0               ; (2) d0=0XX3
move.w     d1,d3               ; (2) d3=X12X
swap       d0                  ; (4) d0=X30X
lsl.l     #8,d0                ; (4) d0=XX30
lsl.l     #8,d3                ; (4) d3=X12X
move.w     d0,d2               ; (2) d2=3030 (YiY0YiY1) (1)
move.w     d3,d1               ; (2) d1=2121 (YiY0YiY1) (2)

```

endm

macro

Y8x2a

&amp;AY,&amp;IND,&amp;UV

GETY

&amp;AY,&amp;IND,&amp;UV,d1,d2

```

move.l    &AY,d2                ; (2+) Y=Y0Y1
lsl.l     #3,d2                 ; (4) Y=Y0XXY1XX
move.b     &UV,d2               ; (2) Y=Y1UV
andi.w     #53FFF,d2           ; (4) Y=0YUV(Y1)
move.l     (&IND,d2.w*4),d1    ; (2+) d1=0123 (Y1)
swap       d2                  ; (4) Y=Y0XX
move.b     &UV,d2               ; (2) Y=Y0UV
andi.w     #53FFF,d2           ; (4) Y=0YUV(Y0)
move.l     (&IND,d2.w*4),d2     ; (2+) d2=0123 (Y0)
move.w     d1,d0               ; (2) exg.w d2,d1
move.w     d2,d1               ; (2) d1=0123 (Y1Y0)
move.w     d0,d2               ; (2) d2=0123 (Y0Y1)
swap       d1                  ; (4) d1=2301 (Y0Y1)

```

endm

macro

Y8x2b

&amp;AY,&amp;IND,&amp;UV

GETY

&amp;AY,&amp;IND,&amp;UV,d1,d2





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Engineering:KlicsCode:CompPict:Colour.a

```

    add.l    a1,d1                ; U.width*height/2
    move.l   d1,LS.U_ey(a6)       ; SAVE U_ey
    add.l    d0,d0                ; width*2
    move.l   d0,LS.Y1(a6)         ; SAVE Y1
    move.l   d0,LS.Y_y(a6)        ; SAVE Y_y
    move.l   PS.rowByte(a6),d1    ; LOAD rowBytes
    add.l    d1,d1                ; rowBytes*2
    add.l    d1,d1                ; rowBytes*4
    sub.l    d0,d1                ; rowBytes*4-width*2
    move.l   d1,LS.P_y(a6)        ; SAVE P_y

    move.l   PS.rowByte(a6),d5    ; load rowBytes
    clr.l    d6
    clr.l    d7

9do_y  move.l   LS.U_ix(a6),d0     ; LOAD U_ixB
    add.l    a1,d0                ; P*U_ixB
    move.l   d0,LS.U_ex(a6)       ; SAVE U_exB

9do_x  GETUV    a1,a2,d0,d4        ; d4=00UV00UV (10)

    Y8x2a     (a0),a4,d4;.d6      ; calc d2,d1 pixels
    move.l    d2,(a3)
    add.l     d5,a3
    move.l    d1,(a3)
    add.l     d5,a3

    move.l    LS.Y1(a6),d0         ; load Yrow
    Y8x2b     (a0,d0.w),a4,d4;.d7 ; calc d2,d1 pixels
    move.l    d2,(a3)
    add.l     d5,a3
    move.l    d1,(a3)+

    swap      d4                  ; next UV
    addq.l    #4,a0               ; next Ya

    move.l    LS.Y1(a6),d0         ; load Yrow
    Y8x2b     (a0,d0.w),a4,d4;.d7 ; calc d2,d1 pixels
    move.l    d1,(a3)
    sub.l     d5,a3
    move.l    d2,(a3)
    sub.l     d5,a3

    Y8x2a     (a0)+,a4,d4;.d6
    move.l    d1,(a3)
    sub.l     d5,a3
    move.l    d2,(a3)+

    cmpa.l    LS.U_ex(a6),a1
    blt.w     9do_x

    add.l     LS.Y_y(a6),a0
    add.l     LS.P_y(a6),a3

    cmpa.l    LS.U_ey(a6),a1
    blt.w     9do_y

    movem.l   (a7)+,d4-d7/a3-a5    ; restore registers
    unlk      a6                  ; remove locals
    rts       ; return

```

ENDFUNC

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Engineering:KlicsCode:CompPict:Colour.a

```

macro
RGB2Y    =    &RGB,&Y,&U,&V,&AY

move.l    &RGB,d2                ; pixel='pixmap
ecr1.l    &S808080,d2            ; pixel'=0x808080
clr.w     d1                     ; B=0
move.b    d2,d1                  ; B=pixel[3]
move.l    4(a4,d1.w*8),d0        ; d0=by,bu
sub.w     d0,&U                  ; U=bu
swap      d0                     ; d0=bu,by
move.w    d0,&Y                  ; Y=by
ext.w     d1                     ; (short)B
add.w     d1,d1                  ; B*=2
add.w     d1,&V                  ; V+=B<<1
lsr.l     &B,d2                  ; pixel>>=8
clr.w     d1                     ; G=0
move.b    d2,d1                  ; G=pixel[3]
move.l    4(a4,d1.w*8),d0        ; d0=gry,gv
sub.w     d0,&U                  ; U=gv
swap      d0                     ; d0=gv,gry
sub.w     d0,&Y                  ; Y=gry
move.l    4(a4,d1.w*8),d0        ; d0=gby,gu
sub.w     d0,&V                  ; V=gby
swap      d0                     ; d0=gu,gby
sub.w     d0,&Y                  ; Y=gby
ext.w     d1                     ; (short)G
sub.w     d1,&U                  ; U=g
sub.w     d1,&V                  ; V=g
lsr.w     &B,d1                  ; G<<=2
add.w     d1,&Y                  ; Y+=B<<1
lsr.l     &B,d2                  ; pixel>>=8
move.l    4(a4,d2.w*8),d0        ; d0=ry,rv
sub.w     d0,&V                  ; V=rv
swap      d0                     ; d0=rv,ry
add.w     d0,&Y                  ; Y=ry
ext.w     d2                     ; (short)R
add.w     d2,d2                  ; R*=2
add.w     d2,&U                  ; U+=R<<2
cmpi.w    &SFE40,&Y              ; Y>=-448
bge.s     &ok                    ; if greater
move.w    &SFE40,&Y              ; Y=-448
bra.s     &end                   ; save
&ok      cmpi.w    &S01C0,&Y      ; Y< 448
          blt.s     &end          ; if less
          move.w    &S01C0,&Y      ; Y=448
&end     move.w    &Y,&AY        ; Save Y

endm

```

| IN32    | FUNC   | EXPORT |
|---------|--------|--------|
| PS      | RECORD | 8      |
| table   | DS.L   | 1      |
| pixmap  | DS.L   | 1      |
| Y       | DS.L   | 1      |
| U       | DS.L   | 1      |
| V       | DS.L   | 1      |
| width   | DS.L   | 1      |
| height  | DS.L   | 1      |
| rowByte | DS.L   | 1      |
|         | ENDR   |        |
| LS      | RECORD | 0,DECR |

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Engineering:KlicsCode:CompPict:Colour.3

```

Y1      DS.L      = 1      : sizeof(short)*Yrow      = 2*width
U_ex    DS.L      1      : x end address          = U+U_ix
U_ey    DS.L      1      : y end address          = U+width*height>>
U_ix    DS.L      1      : sizeof(short)*Uvrow      = width
Y_y     DS.L      1      : sizeof(short)*Yrow      = 2*width
P_y     DS.L      1      : 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize   EQU      .
E2DR

.
.
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

link     a6,#LS.LSize      : inc, width, fend and rowend are loca
movem.l  d4-d7/a3-a5,-(a7) : store registers

move.l   PS.Y(a6),a0       : Y=Yc
move.l   PS.U(a6),a1       : U=Uc
move.l   PS.V(a6),a2       : V=Vc
move.l   PS.pixmap(a6),a3  : pm=pixmap
move.l   PS.table(a6),a4   : tab=table

move.l   PS.width(a6),d0    : LOAD width
move.l   d0,LS.U_ix(a6)    : SAVE U_ix
move.l   PS.height(a6),d1  : LOAD height
mulu.w   d0,d1             : width*height
lsr.l    #1,d1             : width*height/2
add.l    a1,d1             : U+width*height/2
move.l   d1,LS.U_ey(a6)    : SAVE U_ey
add.l    d0,d0             : width*2
move.l   d0,LS.Y1(a6)      : SAVE Y1
move.l   d0,LS.Y_y(a6)     : SAVE Y_y
add.l    d0,d0             : width*4
move.l   PS.rowByte(a6),d1 : LOAD rowBytes
add.l    d1,d1             : rowBytes*2
sub.l    d0,d1             : rowBytes*2-width*4
move.l   d1,LS.P_y(a6)     : SAVE P_y

move.l   PS.rowByte(a6),d7 : load rowBytes
move.l   LS.Y1(a6),d6      : load Y1

2do_y    move.l   LS.U_ix(a6),d0 : LOAD U_ixB
add.l    a1,d0             : P+U_ixB
move.l   d0,LS.U_ex(a6)    : SAVE U_exB

0do_x    clr.w     d4       : U=0
clr.w     d5       : V=0

RGB2Y    (a3,d7.w),d3,d4,d5,(a0,d6.w): Convert pixel
RGB2Y    (a3)+,d3,d4,d5,(a0)+       : Convert pixel
RGB2Y    (a3,d7.w),d3,d4,d5,(a0,d6.w): Convert pixel
RGB2Y    (a3)+,d3,d4,d5,(a0)+       : Convert pixel

asr.w     #2,d4           : U>>=2
asr.w     #2,d5           : V>>=2

cmpi.w    #SFE40,d4       : U>=-448
bge.s     0okU            : if greater
move.w    #SFE40,d4       : U=-448
bra.s     0doV            : save
cmpi.w    #S01C0,d4       : U< 448
blt.s     0doV            : if less
move.w    #S01C0,d4       : U= 448

```

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Engineering:KlicsCode:CompPict:Colour.a

```

@doV    cmpi.w    @, #SF240.d5      ; V>=-448
        bge.s     @okV              ; if greater
        move.w    @SF240.d5        ; V= -448
        bra.s     @end              ; save
@okV     cmpi.w    @S01CC.d5        ; V< 448
        blt.s     @end              ; if less
        move.w    @S01C0.d5        ; V= 448

@end     move.w    d4.(a1)+          ; Save U
        move.w    d5.(a2)+          ; Save V

        cmpa.l    LS.U_ex(a6),a1
        blt.w     @do_x

        add.l     LS.Y_y(a6),a0
        add.l     LS.P_y(a6),a3

        cmpa.l    LS.U_ey(a6),a1
        blt.w     @do_y

        movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
        unlk      a6                ; remove locals
        rts       ; return

```

ENDFUNC

```

-----
macro
UV16      &AO, &AV, &SP, &UV

        move.l    (&AO)+,&SP
        move.l    (&AV)+,&UV
        UVOVER    &SP,&UV
        lsr.l     #5,&UV
        andi.l    #03e003e0,&SP
        andi.l    #001F001F,&UV
        or.l      &SP,&UV          ; UV==000UV00UV
        swap      &UV

        endm

macro
Y16x2     &AY,&IND,&UV

        move.l    &AY,d2           ; (2+) Y=Y0Y1
        lsl.l     #5,d2            ; (4) Y=Y0XXY1XX
        andi.l    #5PC00FC00,d2   ;
        or.w      &UV,d2           ; (2) Y=Y1UV
        move.l    (&IND,d2.w*4),d1 ; (2+) d1=0123 (Y1)
        swap      d2              ; (4) Y=Y0XX
        or.w      &UV,d2           ; (2) Y=Y0UV
        move.l    (&IND,d2.w*4),d2 ; (2+) d2=0123 (Y0)

        endm

```

OUT16x2 FUNC EXPORT

|        |        |   |
|--------|--------|---|
| PS     | RECORD | 8 |
| cable  | DS.L   | 1 |
| pixmap | DS.L   | 1 |
| v      | DS.L   | 1 |
| U      | DS.L   | 1 |
| V      | DS.L   | 1 |

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Engineering:KlincsCode:CompPict:Colour.a

```

width    DS.L    F
height   DS.L    1
rowByte  DS.L    1
pixmap   DS.L    1
        ENDR
.
LS        RECORD    0,DECR
Y1        DS.L    1      ; sizeof(short)*Yrow      = 2*width
U_ex      DS.L    1      ; x end address      = U+U_ix
U_ey      DS.L    1      ; y end address      = U*width*height>>
U_ix      DS.L    1      ; sizeof(short)*UVrow = width
Y_y       DS.L    1      ; sizeof(short)*Yrow  = 2*width
P_y       DS.L    1      ; 4*rowBytes-sizeof(long)*Prow = 4*rowBytes-width
LSize     EQU      *
        ENDR
.
.      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
.      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7
.
        link      a6,#LS.LSize      ; inc. width, fend and rowend are loca
        movem.l   d4-d7/a3-a5,-(a7) ; store registers
.
        move.l    PS.Y(a6),a0      ; Y=Yc
        move.l    PS.U(a6),a1      ; U=Uc
        move.l    PS.V(a6),a2      ; V=Vc
        move.l    PS.pixmap(a6),a3 ; pm=pixmap
        move.l    PS.table(a6),a4   ; tab=table
        adda.l    #500020000,a4     ; tab+=32768 (longa)
        move.l    PS.pixmap2(a6),a5 ; pm2=pixmap2
.
        move.l    PS.width(a6),d0   ; LOAD width
        move.l    d0,LS.U_ix(a6)    ; SAVE U_ix
        move.l    PS.height(a6),d1  ; LOAD height
        mulu.w    d0,d1             ; width*height
        lsr.l     #1,d1             ; width*height/2
        add.l     a1,d1             ; U*width*height/2
        move.l    d1,LS.U_ey(a6)    ; SAVE U_ey
        add.l     d0,d0             ; width*2
        move.l    d0,LS.Y1(a6)      ; SAVE Y1
        move.l    d0,LS.Y_y(a6)     ; SAVE Y_y
        add.l     d0,d0             ; width*4
        move.l    PS.rowByte(a6),d1 ; LOAD rowBytes
        add.l     d1,d1             ; rowBytes*2
        add.l     d1,d1             ; rowBytes*4
        sub.l     d0,d1             ; rowBytes*4-width*4
        move.l    d1,LS.P_y(a6)     ; SAVE P_y
.
        move.l    PS.rowByte(a6),d5 ; load rowBytes
        clr.l     d6
        clr.l     d7
.
@do_y     move.l    LS.U_ix(a6),d0   ; LOAD U_ixB
        add.l     a1,d0             ; P+U_ixB
        move.l    d0,LS.U_ex(a6)    ; SAVE U_exB
.
@do_x     GETOV      a1,a2,d0,d4     ; d4=00UV00UV (10)
.
        GETY      (a0),a4,d4,d1,d2 ; calc d2,d1 pixel
        move.l    d2,(a3)+
        move.l    d1,(a3)
        add.l     d5,a3
        swap      d1
        move.l    d1,(a3)

```

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Engineering:KlicsCode:CompPict:Colour.a

```

swap      d2
move.l    d2,-(a3)
add.l     d5,a3

move.l    LS.Y1(a6),d0      ; load Yrow
GETY      (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
move.l    d2,(a3)+
move.l    d1,(a3)
add.l     d5,a3
swap      d1
move.l    d1,(a3)
swap      d2
move.l    d2,-(a3)

swap      d4                ; next UV
addq.l    #4,a0              ; next Ya
add.l     #12,a3

move.l    LS.Y1(a6),d0      ; load Yrow
GETY      (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
move.l    d1,(a3)
move.l    d2,-(a3)
sub.l     d5,a3
swap      d2
move.l    d2,(a3)+
swap      d1
move.l    d1,(a3)
sub.l     d5,a3

GETY      (a0)+,a4,d4,d1,d2
move.l    d1,(a3)
move.l    d2,-(a3)
swap      d2
sub.l     d5,a3
move.l    d2,(a3)+
swap      d1
move.l    d1,(a3)+

cmpa.l    LS.U_ex(a6),a1
blt.w     @do_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS.U_ey(a6),a1
blt.w     @do_y

movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
unlk      a6                ; remove locals
rts       ; return

```

ENDFUNC

```

-----
macro
Y16      6AY,6IND,6UV

move.l    6AY,d2              ; (2+) Y=Y0Y1
lsl.l     #5,d2               ; (4) Y=Y0XXY1XX
andi.l    #5FC00FC00,d2      ;
or.w      6UV,d2              ; (2) Y=Y1UV
move.l    (6IND,d2.w*4),d1    ; (2+) d1=Y1
swap      d2                  ; (4) Y=Y0XX
or.w      6UV,d2              ; (2) Y=Y0UV

```

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Engineering:KlicsCode:CcmpPict:Colour.a

```

move.l (4*IND.d2.w*4).d2 : (2-) d2=Y0
move.w d1,d2 : (2) d2=Y0Y1

endm

CUT16 FUNC EXPORT
PS RECORD 8
table DS.L 1
pixmap DS.L 1
Y DS.L 1
U DS.L 1
V DS.L 1
width DS.L 1
height DS.L 1
rowByte DS.L 1
pixmap2 DS.L 1
ENDR

LS RECORD 0,DECR
Yl DS.L 1 ; sizeof(short)*Yrow = 2*width
U_ex DS.L 1 ; x end address = U-U_ix
U_ey DS.L 1 ; y end address = U+width*height>>
U_ix DS.L 1 ; sizeof(short)*Uvrow = width
Y_y DS.L 1 ; sizeof(short)*Yrow = 2*width
P_y DS.L 1 ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize EQU
ENDR

a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

link a6,%LS.LSize ; inc, width, fend and rowend are loca
movem.l d4-d7/a3-a5,-(a7) ; store registers

move.l PS.Y(a6),a0 ; Y=Yc
move.l PS.U(a6),a1 ; U=Uc
move.l PS.V(a6),a2 ; V=Vc
move.l PS.pixmap(a6),a3 ; pm=pixmap
move.l PS.table(a6),a4 ; tab=table
adda.l #500020000,a4 ; tab+=32768 (longs)
move.l PS.pixmap2(a6),a5 ; pm2=pixmap2

move.l PS.width(a6),d0 ; LOAD width
move.l d0,LS.U_ix(a6) ; SAVE U_ix
move.l PS.height(a6),d1 ; LOAD height
mulu.w d0,d1 ; width*height
lsr.l #1,d1 ; width*height/2
add.l a1,d1 ; U+width*height/2
move.l d1,LS.U_ey(a6) ; SAVE U_ey
add.l d0,d0 ; width*2
move.l d0,LS.Yl(a6) ; SAVE Yl
move.l d0,LS.Y_y(a6) ; SAVE Y_y
move.l PS.rowByte(a6),d1 ; LOAD rowBytes
add.l d1,d1 ; rowBytes*2
sub.l d0,d1 ; rowBytes*2-width*2
move.l d1,LS.P_y(a6) ; SAVE P_y

move.l PS.rowByte(a6),d5 ; load rowBytes
clr.l d6
clr.l d7

edo_y move.l LS.U_ix(a6),d0 ; LOAD U_ixB

```



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Engineering:KlicsCode:CompPic:Colour.e

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```

      add.l    a4,d0                ; P+U_ix8
      move.l   d0,LS_U_ex(a6)      ; SAVE U_ex8
3dc_x  GETUV    a1,a2,d0,d4        ; d4=00UV00UV (10)
      GETY     (a0),a4,d4,d1,d2    ; calc d2,d1 pixel
      move.w   d1,d2
      move.l   d2,(a3)
      add.l    d5,a3

      move.l   LS_Y1(a6),d0        ; load Yrow
      GETY     (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
      move.w   d1,d2
      move.l   d2,(a3)+

      swap     d4                  ; next UV
      addq.l   #4,a0              ; next Ys

      move.l   LS_Y1(a6),d0        ; load Yrow
      GETY     (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
      move.w   d1,d2
      move.l   d2,(a3)
      sub.l    d5,a3

      GETY     (a0)+,a4,d4,d1,d2
      move.w   d1,d2
      move.l   d2,(a3)+

      cmpa.l   LS_U_ex(a6),a1
      blt.w    @do_x

      add.l    LS_Y_y(a6),a0
      add.l    LS_P_y(a6),a3

      cmpa.l   LS_U_ey(a6),a1
      blt.w    @do_y

      movem.l  (a7)+,d4-d7/a3-a5   ; restore registers
      unlk     a6                  ; remove locals
      rts                      ; return

      ENDFUNC
-----
      END

```

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Engineering:KlicsCode:CompPict:Color2.a

```

-----
:
:  © Copyright 1993 KLICS Limited
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:
:  Written by: Adrian Lewis
:
-----
:
:  6E000 Fast RGB/YUV code
:
-----
:  include 'Traps.a'
:  machine mc68030
:
-----
:  macro
:  RGB2Y    &Apixel,&AY
:
:  d0 - pixel/r, d1 - g/2g+r, d2 - b, d3 - Y
:
:  move.l    &Apixel,d0      ; pixel=&Apixel
:  eor.l     #500808080,d0   ; signed pixels
:
:  move.b    d0,d2           ; b=pixel[3]
:  ext.w     d2              ; b is 8(16) bit
:
:  move.w     d0,d1          ; g=pixel[2]
:  asr.w     #7,d1           ; 2g is 9(16) bit
:
:  swap      d0              ; r=pixel[1]
:  ext.w     d0              ; r is 8(16) bit
:
:  move.w     d2,d3          ; Y=b
:  lsl.w     #3,d3           ; Y<<=3
:  sub.w     d2,d3           ; Y-=b
:
:  add.w     d0,d1           ; 2g+r
:  add.w     d1,d3           ; Y+=2g+r
:  add.w     d1,d3           ; Y+=2g+r
:  add.w     d1,d3           ; Y+=2g+r
:  asr.w     #4,d3           ; Y>>=4
:  add.w     d1,d3           ; Y+=2g+r
:  move.w     d3,&AY         ; AY=Y is 10(16) bit
:
:  endm
:
-----
:  macro
:  RGB2UV    &AU,&AV
:
:  d0 - r, d2 - b, d3 - Y, d1 - U/V
:
:  add.w     d0,d0           ; r is 9(16) bit
:  add.w     d2,d2           ; b is 9(16) bit
:  asr.w     #1,d3           ; Y is 9(16) bit
:  move.w     d2,d1          ; U=b
:  sub.w     d3,d1           ; U=b-Y
:  move.w     d1,&AU         ; AU=U
:  move.w     d0,d1          ; V=r
:  sub.w     d3,d1           ; V=r-Y
:  move.w     d1,&AV         ; AV=V
:
:  endm
:
-----

```

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Engineering:KlicsCode:CompPict:Color2.a

```

if &TYPE('seg')='UNDEFINED' then
seg      &seg
endif

RGB2YUV2      FUNC      EXPORT
.
      link      a6,#0      ; no local variables
      movem.l   d4-d7/a3,-(a7)      ; store registers
.
      move.l    $0008(a6),a3      ; pm= pixmap
      move.l    $000C(a6),a0      ; Y=Yc
      move.l    $0010(a6),a1      ; U=Uc
      move.l    $0014(a6),a2      ; V=Vc
      move.l    $0018(a6),d7      ; fend=area
      asl.l     #2,d7      ; fend<<=2
      add.l     a3,d7      ; fend+=pm
      move.l    $001C(a6),d4      ; width_b=width
      asl.l     #2,d4      ; width_b<<=2
      move.l    $0020(a6),d5      ; inc_b=cols
      asl.l     #2,d5      ; cols<<=2
      sub.l     d4,d5      ; inc_b-=width_b
      @do1      move.l    a3,d6      ; rowend=pm
      add.l     d4,d6      ; rowend+=width_b
      @do2      rgb2y     (a3)+,(a0)+      ; rgb2y(pm++,Y++)
      rgb2uv    (a1)+,(a2)+      ; rgb2uv(U++,V++)
      rgb2y     (a3)+,(a0)+      ; rgb2y(pm++,Y++)
      cmpa.l    d6,a3      ; rowend>pm
      blt.s     @do2      ; while
      adda.l    d5,a3      ; pm+=inc_b
      move.l    a3,d6      ; rowend=pm
      add.l     d4,d6      ; rowend+=width_b
      @do3      rgb2y     (a3)+,(a0)+      ; rgb2y(pm++,Y++)
      cmpa.l    d6,a3      ; rowend>pm
      blt.s     @do3      ; while
      adda.l    d5,a3      ; pm+=inc_b
      cmpa.l    d7,a3      ; fend>pm
      blt.w     @do1      ; while -
.
      movem.l   (a7)+,d4-d7/a3      ; restore registers
      unlk      a6      ; remove locals
      rts      ; return
.
      ENDFUNC
.-----
      macro
      FETCHY      &AY, &Y, &R, &G, &B
.
      move.l     &AY,&Y      ; Y+=AY++
      add.l     &Y,&R      ; RR+=Y12
      add.l     &Y,&G      ; GG+=Y12
      add.l     &Y,&B      ; BB+=Y12
.
      endm
.-----
      macro
      FIXOV      &V, &SP1, &SP2
.
      move.w     &V,&SP1
      clr.b     &SP1
      andi.w     $03FFF,&SP1
      sne      &SP1
      btst     #13,&SP1
      seq      &SP2
.

```

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Engineering:KlacsCode:CompPict:Color2.a

```

or.b      &SP1,&V
and.w     &SP2,&V
swap      &V
move.w    &V,&SP1
clr.b     &SP1
andl.w    &03FFF,&SP1
sne       &SP1
btst      &13,&SP1
seq       &SP2
or.b      &SP1,&V
and.w     &SP2,&V
swap      &V
.
endm
-----
macro
OVERFLOW    &A, &B, &SP1, &SP2
.
.   move.l    &0FFF00FF00,&SP1      ; sp1=mask
.   move.l    &A,&SP2                ; sp2=ovcv (A)
.   and.l     &SP1,&SP2              ; sp2=0000 (A)
.   lsr.l     &8,&SP2                ; sp2=0000 (A)
.   and.l     &B,&SP1                ; sp1=0000 (B)
.   or.l      &SP2,&SP1              ; sp1=0000 (EABA)
.   move.l    &A,&SP1
.   or.l      &B,&SP1
.   andl.l    &0FFF00FF00,&SP1
.   beq.s     0ok                    ; if no overflow
.   clr.w     &SP2'                  ; AND=0
.   FIXOV     &A,&SP1,&SP2            ; A1 overflow
.   FIXOV     &B,&SP1,&SP2            ; B1 overflow
6ok
.
endm
-----
macro
MKRGB       &R, &G, &B, &ARGB
.
.   lsl.l     &8,&G                  ; G=GGGG (12)
.   or.l      &B,&G                  ; G=GBGB (12)
.   move.l    &R,&B                  ; B=0R0R (12)
.   swap      &B                    ; B=0R0R (21)
.   move.w    &G,&B                  ; B=0RGB (2)
.   swap      &G                    ; G=GBGB (21)
.   move.w    &G,&R                  ; R=0RGB (1)
.   move.l    &R,&ARGB               ; *RGB++=rgb (1)
.   move.l    &B,&ARGB               ; *RGB++=rgb (2)
.
endm
-----
macro
DUPVAL      &V0, &V1
.
.   move.w    &V0,&V1                ; v1=v0
.   swap      &V0
.   move.w    &V1,&V0                ; dup v0
.   move.l    &V0,&V1                ; dup v1
.
endm
-----
macro
UV2RGB3     &AU,&AV

```

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Engineering:KilicsCode:CompPict:Color2.a

```

d1 - ra, d2 - ga, d3 - ba, d4 - rb, d5 - gb/512, d6 - bb

```

```

move.w    *512,d5          ; d5=512
move.w    &AU,d2           ; U=*AU--
add.w     d2,d2            ; U is 10(16) bits
move.w    d2,d3           ; ba=U
add.w     d3,d2            ; ga=2U
add.w     d3,d2            ; ga=3U
add.w     d5,d3            ; ba+=512
DUPVAL    d3,d6            ; ba=bb=BB
asr.w     *4,d2            ; ga=3U>>4
move.w    &AV,d1           ; V=*AV--
add.w     d1,d2            ; ga+=V
add.w     d1,d1            ; ra*=2
add.w     d5,d1            ; ra+=512
DUPVAL    d1,d4            ; ra=rb=RR
sub.w     d2,d5            ; gb=512-ga
DUPVAL    d5,d2            ; ga=gb=GG

```

```

endm

```

```

-----
if &TYPE('seg')<'UNDEFINED' then
seg      &seg
endif

```

```

YUV2RGB2      FUNC      EXPORT

```

```

PS            RECORD      8
pixmap        DS.L        1
Y             DS.L        1
U             DS.L        1
V             DS.L        1
area          DS.L        1
width         DS.L        1
cols          DS.L        1
ENDR

```

```

LS            RECORD      0,DECR
inc           DS.L        1
width         DS.L        1
fend          DS.L        1
count         DS.L        1
LSize         EQU         *
ENDR

```

```

a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
d0..6 - used, d7 - count

```

```

link         a6,0LS.LSize      ; inc, width, fend and rowend are loca
movem.l      d4-d7/a3-a5,-(a7) ; store registers

```

```

move.l       PS.pixmap(a6),a4   ; pm0=pixmap
move.l       a4,a5              ; pm1=pm0
move.l       PS.Y(a6),a0        ; Y0=Yc
move.l       a0,a1              ; Y1=Y0
move.l       PS.U(a6),a2        ; U=Uc
move.l       PS.V(a6),a3        ; V=Vc
move.l       PS.area(a6),d7     ; fend=area
lsl.l        #2,d7              ; fend<<=2
add.l        a4,d7              ; fend+=pm0
move.l       d7,LS.fend(a6)     ; save fend
move.l       PS.width(a6),d5    ; width=width
move.l       d5,d7              ; count=width

```

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Engineering:Kl:csCode:CompPict:Color2.a

```

asr.l      #1,d7                ; count>>=1
subq.l     #1,d7                ; count-=1
move.l     d7,PS,width(a6)      ; save width
add.l      d5,d5                ; width*=2
add.l      d5,a1                ; Y1+=width
add.l      d5,d5                ; width*=2
move.l     d5,LS,width(a6)      ; save width
move.l     PS,cols(a6),d4       ; inc=cols
lsl.l      #2,d4                ; inc<<=2
add.l      d4,a5                ; pm1+=inc
add.l      d4,d4                ; cols*=2
sub.l      d5,d4                ; inc now 2*cols-width bytes
move.l     d4,LS,inc(a6)        ; save inc
edo        UV2RGB3              ; uv2rgb(*U+*,*V+*)
FETCHMY    (a0)+,d0,d1,d2,d3    ; add Ya to RGB values
FETCHMY    (a1)+,d4,d5,d6      ; add Yb to RGB values
move.w     #53FFF,d0           ; d0=mask
lsl.l      #2,d1                ; d1 8(16) bits
and.w      d0,d1                ; d1 masked
lsl.l      #2,d2                ; d2 8(16) bits
and.w      d0,d2                ; d2 masked
lsl.l      #2,d3                ; d3 8(16) bits
and.w      d0,d3                ; d3 masked
lsl.l      #2,d4                ; d4 8(16) bits
and.w      d0,d4                ; d4 masked
lsl.l      #2,d5                ; d5 8(16) bits
and.w      d0,d5                ; d5 masked
lsl.l      #2,d6                ; d6 8(16) bits
and.w      d0,d6                ; d6 masked
move.l     d1,d0
or.l       d2,d0
or.l       d3,d0
or.l       d4,d0
or.l       d5,d0
or.l       d6,d0
andi.l     #5FFF00FF,d0
0ok        bne.s 0over          ; if overflow
MKRGB      d1,d2,d3,(a4)+       ; save RGBa
MKRGB      d4,d5,d6,(a5)+       ; save RGBb
dbf        d7,0do              ; while
adda.l     LS,inc(a6),a4        ; pm0+=inc
adda.l     LS,inc(a6),a5        ; pm1+=inc
adda.l     LS,width(a6),a0      ; Y0+=width
exp.l      a0,a1                ; Y1<->Y0
move.l     PS,width(a6),d7      ; count=width
cmpa.l     LS,fend(a6),a4       ; pm0<fend
blt.w      0do                 ; while
move.l     (a7)+,d4-d7/a3-a5    ; restore registers
unlk       a6                  ; remove locals
rts        ; return
0over      move.l  d7,LS,count(a6) ; save count
clr.w      d7                  ; AND=0

FIXOV      d1,d0,d7            ; A overflow
FIXOV      d2,d0,d7            ; B overflow
FIXOV      d3,d0,d7            ; A overflow
FIXOV      d4,d0,d7            ; B overflow
FIXOV      d5,d0,d7            ; A overflow
FIXOV      d6,d0,d7            ; B overflow
move.l     LS,count(a6),d7      ; restore count
bra        0ok

```

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Engineering:KlicsCode:CompPict:Color2.a

```

ENDFUNC
-----
if &TYPE('seg')='UNDEFINED' then
seg      &seg
endif

GREY2Y   FUNC      EXPORT
.
PS       RECORD      8
pixmap   DS.L        1
Y         DS.L        1
area      DS.L        1
width     DS.L        1
cols      DS.L        1
        ENDR
.
d0 - vvvv, d1 - v0v1, d2 - v2v3, d3 - xor, d4 - width, d5 - inc, d6 - rowend,
a0 - pm, a1 - Y
.
        link        a6,#0                ; no local variables
        movem.l     d4-d7,-(a7)          ; store registers
.
        move.l      PS.pixmap(a6),a0    ; pm=pixmap
        move.l      PS.Y(a6),a1         ; Y=Yc
        move.l      PS.area(a6),d7      ; fend=area
        add.l       a0,d7                ; fend+=pm
        move.l      PS.width(a6),d4     ; width_b=width
        move.l      PS.cols(a6),d5      ; inc_b=cols
        sub.l       d4,d5                ; inc_b-=width_b
        move.l      #57F7F7F7,d3        ; xor=57F7F7F7
@do1      move.l     a0,d6                ; rowend=pm
        add.l       d4,d6                ; rowend+=width_b
@do2      move.l     (a0)+,d0             ; vvvv=pm
        eor.l       d3,d0                ; vvvv is signed
        move.w      d0,d2                ; d2=v2v3
        asr.w       #6,d2                ; d2=v2 (10 bits)
        swap       d2                    ; d2=v2??
        move.b      d0,d2                ; d2=v2v3
        ext.w       d2                    ; v3 extended
        lsl.w       #2,d2                ; d2=v2v3 (10 bits)
        swap       d0                    ; d0=v0v1
        move.w      d0,d1                ; d1=v0v1
        asr.w       #6,d1                ; d1=v0 (10 bits)
        swap       d1                    ; d1=v0??
        move.b      d0,d1                ; d1=v0v1
        ext.w       d1                    ; v1 extended
        lsl.w       #2,d1                ; d1=v0v1 (10 bits)
        move.l      d1,(a1)+             ; *Y=d1
        move.l      d2,(a1)+             ; *Y=d2
        cmpa.l      d6,a0                ; rowend>pm
        blt.s       @do2                ; while
        adda.l      d5,a0                ; pm+=inc_b
        cmpa.l      d7,a0                ; fend>pm
        blt.s       @do1                ; while
.
        movem.l     (a7)+,d4-d7          ; restore registers
        unlink      a6                  ; remove locals
        rts
.
ENDFUNC
-----
if &TYPE('seg')='UNDEFINED' then
seg      &seg
endif

```

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Engineering:KlicsCode:CompPict:Color2.a

```

endif
Y2GREY FUNC EXPORT
PS RECORD 3
pixmap DS.L 1
Y DS.L 1
height DS.L 1
width DS.L 1
cols DS.L 1
ENDR
.
. c0- spare, d1 - v43, d2 - v21, d3 - spare, d4 - width, d5 - inc, d6 - count, d
. a0 - pm, a1 - Y
.
link a6,#0 ; no local variables
movem.l d4-d7,-(a7) ; store registers
.
move.l PS.pixmap(a6),a0 ; pm=pixmap
move.l PS.Y(a6),a1 ; Y=Yc
move.l PS.height(a6),d7 ; long height
subq.l #1,d7 ; height-=1
move.l PS.width(a6),d4 ; long width
move.l PS.cols(a6),d5 ; long inc=cols
sub.l d4,d5 ; inc-=width
lsl.l #2,d4 ; width>>=2 (read 4 values)
subq.l #1,d4 ; width-=1
@do1 move.l d4,d6 ; count=width
@do2 move.l (a1)+,d0 ; d0=x4x3
move.l (a1)+,d1 ; d1=x2x1
move.l #501FF01FF,d2 ; d2=511
move.l d2,d3 ; d3=511
sub.l d0,d2 ; unsigned d2
sub.l d1,d3 ; unsigned d3
lsl.l #2,d2
lsl.l #2,d3
move.l d2,d0
or.l d3,d0
andi.l #53F002F00,d0
bne.s @over ; if no overflow
@ok lsl.l #8,d3 ; d3=0210
lsl.l #8,d2 ; d2=0410
lsl.l #8,d3 ; d3=0021
lsl.l #8,d2 ; d2=4100
or.l d3,d2 ; d2=4321
move.l d2,(a0)+ ; *pm=d2
dbf d6,@do2 ; while -1!--count
adda.l d5,a0 ; pm+=inc_b
dbf d7,@do1 ; while -1!--height
.
movem.l (a7)+,d4-d7 ; restore registers
unlk a6 ; remove locals
rts ; return
@over clr.w d1 ; AND=0
FIXOV d2,d0,d1 ; A overflow
FIXOV d3,d0,d1 ; B overflow
bra.s @ok
.
ENDFUNC
-----
macro
GCC &V,&SP1,&SP2,&AV

```



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Engineering:KlicsCode:CompPict:Color3.2

```

move.l    &V,&SP2                : SP2=0102
lsl.l     &SP2                    : SP2=1020
or.l      &V,&SP2                  : SP2=1122
move.l    &V,&SP1                  : SP1=0102
swap      &SP1                    : SP1=0201
move.w    &SP2,&SP1                : SP1=0222
swap      &SP2                    : SP2=2211
move.w    &SP2,&V                  : V=0111
move.l    &V,&AV                    : *pm=V
move.l    &SP1,&AV                  : *pm=SP1

endm

-----
if &TYPE('seg')*UNDEFINED then
seg      &seg
endif

Y2GGG    FUNC      EXPORT
*
PS        RECORD      8
pixmap    DS.L        1
Y          DS.L        1
lines     DS.L        1
width     DS.L        1
cols      DS.L        1
ENDR

*
*   d0 - v, d4 - width, d5 - inc, d6 - count, d7 - lines
*   a0 - pm, a1 - Y
*
link      a6,#0                    : no local variables
movem.l   d4-d7,-(a7)              : store registers

*
move.l     PS,pixmap(a6),a0        : pm=pixmap
move.l     PS,Y(a6),a1             : Y=Yc
move.l     PS,lines(a6),d7         : long lines
subq.l     #1,d7                   : lines-=1
move.l     PS,width(a6),d4         : long width
move.l     PS,cols(a6),d5          : inc=cols
sub.l      d4,d5                   : inc-=width
lsl.l      #2,d5                   : inc (bytes)
lsr.l      #2,d4                   : width>>=2
subq.l     #1,d4                   : width-=1
?dc1      move.l     d4,d6          : count=width
?dc2      move.l     (a1)-,d0        : d0=x1x2 (10 bits signed)
          move.l     (a1)-,d1        : d1=x3x4 (10 bits)
          move.l     #0200C200,d3    : d3=plus
          add.l      d3,d0           : d0=x1x2 (unsigned)
          add.l      d3,d1           : d1=x3x4 (unsigned)
          lsr.l      #2,d0           : d0=x1x2 (10,8 bits)
          lsr.l      #2,d1           : d1=x3x4 (10,8 bits)
          move.w     #03FFF,d2       : d2=mask
          and.w      d2,d0           : mask d0
          and.w      d2,d1           : mask d1
          move.l     d0,d2
          or.l       d1,d2
          andi.l     #0FFF00FF,d2
          bne.s      @over           : if no overflow
?ok      GGG         d0,d2,d3,(a0)+
          GGG         d1,d2,d3,(a0)+
          dbf         d6,@dc2        : while -1!--count
          adda.l      d5,a0           : pm+=inc_b
          dbf         d7,@dc1        : while -1!--lines

```

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= Engineering:KlacsCode:CompProc:Color2.a

```

movem.l    (a7)-,d4-d7      : restore registers
unix       a6               : remove locals
rts        : return
over       clr.w            d3      : AND=0
FIXOV      d0,d2,d3         : A overflow
FIXOV      d1,d2,d3         : B overflow
bra.w      2ok

```

-----

```

ENDFUNC

```

-----

```

macro
MRGB2      &R, &G, &B, &ARGB, &ROW, &XX

    lsl.l   &B,&G           : G=G0G0 (12)
    or.l    &B,&G           : G=GBGB (12)
    move.l  &R,&B           : B=0R0R (12)
    swap    &B              : B=0R0R (21)
    move.w  &G,&B           : B=0RGB (2)
    swap    &G              : G=GBGB (21)
    move.w  &G,&R           : R=0RGB (1)

    andi.l  *FFFFFFFE,&R    : 7 bits for interpolation
    andi.l  *FFFFFFFE,&B    : 7 bits for interpolation

    move.l  &R,&G           : G=RGB(1)
    add.l   &B,&G           : G+=RGB(2)
    lsr.l   &G,2            : G/=2

    move.l  &B,&XX          : XX=RGB(2)
    sub.l   &R,&XX          : XX-=RGB(1)
    lsr.l   &XX,2           : XX/=2
    add.l   &B,&XX          : XX+=B

    move.l  &R,(&ARGB)+     : *RGB+=rgb (1)
    move.l  &G,(&ARGB)+     : *RGB+=rgb (1.5)
    move.l  &B,(&ARGB)+     : *RGB+=rgb (2)
    move.l  &B,(&ARGB)+     : *RGB+=rgb (2.5)

    add.l   &ROW,&ARGB
    sub.l   #16,&ARGB

    move.l  &R,(&ARGB)+     : *RGB+=rgb (1)
    move.l  &G,(&ARGB)+     : *RGB+=rgb (1.5)
    move.l  &B,(&ARGB)+     : *RGB+=rgb (2)
    move.l  &B,(&ARGB)+     : *RGB+=rgb (2.5)

    sub.l   &ROW,&ARGB

endm

```

-----

```

if &TYPE('seg')='UNDEFINED' then
seg      &seg
endif

```

| YUV2RGB3 | FUNC   | EXPORT |
|----------|--------|--------|
| PS       | RECORD | 0      |
| pixmap   | DS.L   | 1      |
| Y        | DS.L   | 1      |
| U        | DS.L   | 1      |
| V        | DS.L   | 1      |
| area     | DS.L   | :      |

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Engineering:KlincsCode:CompPict:Color2.a

```

width DS.L 1
cols DS.L 1
ENDR
.
LS RECORD 0,DECR
inc DS.L 1
width DS.L 1
fend DS.L 1
count DS.L 1
row DS.L 1
LSize EQU .
ENDR
.
a0 = Y0, a1 = Y1, a2 = U, a3 = V, a4 = pm0, a5 = pm1
d0..6 = used, d7 = count
.
link a6,#LS.LSize ; inc. width, fend and rowend are loca
movem.l d4-d7/a3-a5,-(a7) ; store registers
.
move.l PS.pixmap(a6),a4 ; pm0=pixmap
move.l a4,a5 ; pm1=pm0
move.l PS.Y(a6),a0 ; Y0=Yc
move.l a0,a1 ; Y1=Y0
move.l PS.U(a6),a2 ; U=Uc
move.l PS.V(a6),a3 ; V=Vc
move.l PS.area(a6),d7 ; fend=area
lsl.l #2,d7 ; fend<<=2
add.l a4,d7 ; fend+=pm0
move.l d7,LS.fend(a6) ; save fend
move.l PS.width(a6),d5 ; width=width
move.l d5,d7 ; count=width
asr.l #1,d7 ; count>>=1
subq.l #1,d7 ; count-=1
move.l d7,PS.width(a6) ; save width
add.l d5,d5 ; width*=2
add.l d5,a1 ; Y1=width
add.l d5,d5 ; width*=2
move.l d5,LS.width(a6) ; save width
move.l PS.cols(a6),d4 ; inc=cols
lsl.l #2,d4 ; inc<<=2
move.l d4,LS.row(a6) ; *NEW save row
add.l d4,a5 ; pm1+=inc
add.l d4,a5 ; *NEW pm1+=inc
add.l d4,d4 ; cols*=2
add.l d4,d4 ; *NEW cols*=2
sub.l d5,d4 ; inc now 4*cols-width bytes
sub.l d5,d4 ; *NEW inc now 4*cols-width bytes (wid
move.l d4,LS.inc(a6) ; save inc
@do UV2RGB3 (a2)+,(a3)+ ; uv2rgb(*U++,*V++)

FETCHY (a0)+,d0,d1,d2,d3 ; add Ya to RGB values
FETCHY (a1)+,d0,d4,d5,d6 ; add Yb to RGB values

move.w #3FFF,d0 ; d0=mask
lsl.l #2,d1 ; d1 8(16) bits
and.w d0,d1 ; d1 masked
lsl.l #2,d2 ; d2 8(16) bits
and.w d0,d2 ; d2 masked
lsl.l #2,d3 ; d3 8(16) bits
and.w d0,d3 ; d3 masked
lsl.l #2,d4 ; d4 8(16) bits
and.w d0,d4 ; d4 masked
lsl.l #2,d5 ; d5 8(16) bits

```

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Engineering:Kl:csCode:CompPict:Color3.3

```

and.w    d0,d5          ; d5 masked
lsl.l    #2,d5          ; d6 8(16) bits
and.w    d0,d5          ; d6 masked

move.l    d1,d0
cr.l     d2,d0
cr.l     d3,d0
cr.l     d4,d0
cr.l     d5,d0
cr.l     d6,d0
andi.l    #5FFF00FF00,d0 ; if overflow
bne.w     eover

9ok      MKRGB2    d1,d2,d3,a4,LS,row(a6),d0 ; *NEW save RGBA
MKRGB2    d4,d5,d6,a5,LS,row(a6),d0 ; *NEW save RGBb
dbf       d7,edo        ; while
adda.l    LS,inc(a6),a4   ; pm0+=inc
adda.l    LS,inc(a6),a5   ; pm1+=inc
adda.l    LS,width(a6),a0 ; Y0==width
exg.l     a0,a1          ; Y1<->Y0
move.l    PS,width(a6),d7 ; count=width
cmpa.l    LS,fend(a6),a4 ; pm0<fend
blt.w     edo            ; while

movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
unlk      a6              ; remove locals
rts       ; return
3over     move.l    d7,LS,count(a6) ; save count
clr.w     d7              ; AND=0
FIXOV     d1,d0,d7        ; A overflow
FIXOV     d2,d0,d7        ; B overflow
FIXOV     d3,d0,d7        ; A overflow
FIXOV     d4,d0,d7        ; B overflow
FIXOV     d5,d0,d7        ; A overflow
FIXOV     d6,d0,d7        ; B overflow
move.l    LS,count(a6),d7 ; restore count
bra       9ok

-----
macro
FETCHY2    &AY, &Y, &R, &G, &B
; Y
move.l    &AY,&Y
asr.w     #2,&Y
swap     &Y
asr.w     #2,&Y
swap     &Y
add.l     &Y,&R
add.l     &Y,&G
add.l     &Y,&B
; Y is -128 to -127
; RED, Get (Y- 2V + 512) for Red = (Y +
; GREEN, Get (Y + (512 - (6U/16)) - V)
; BLUE, Get (Y - (2U + 512) for Blue = (
endm

-----
macro
UV2RGB4    &AU, &AV
; U
move.w    &AU,d2
and.w     #503FF,d2
move.l    (a6,d2.w*8),d3
move.l    d3,d6
move.l    4(a6,d2.w*8),d5
move.w    &AV,d1
; V
; BLUE, Get (2U + 512)/4 for Blue = (Y -
; Dup for second pair
; GREEN, Get (512 - (6U/16))/4 for Gree

```

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Engineering:KlucCode:CompPict:Color3.a

```

move.w    d1,d4
asr.w     #2,d1
sub.w     d1,d5           ;GREEN, Get (512 - (EU/16) - V)/4 for
move.w     d5,d2
swap      d5
move.w     d2,d5
move.l     d5,d2           ;Dup for second pair

and.w     #503FF,d4
move.l     (a6,d4.w*8),d4   ;RED, Get (2V + 512)/4 for Red = 1Y -
move.l     d4,d1

```

```

endm
-----

```

```

MKRGB2SUB  FUNC      EXPORT

```

```

MKRGB2     d1,d2,d3,a4,d7,d0 ;*NEW save RGBA
MKRGB2     d4,d5,d6,a5,d7,d0 ;*NEW save RGBb
rts

```

```

ENDFUNC

```

```

OVERSUB  FUNC      EXPORT

```

```

move.l     d1,d0
or.l       d2,d0
or.l       d3,d0
or.l       d4,d0
or.l       d5,d0
or.l       d6,d0
andi.l     #5FFF00FF00,d0
bne.s      $over      ; if overflow
$ok
rts
$over
move.l     d7,-(sp)      ; save count
clr.w      d7           ; AND=0
FIXOV      d1,d0,d7      ; A overflow
FIXOV      d2,d0,d7      ; B overflow
FIXOV      d3,d0,d7      ; A overflow
FIXOV      d4,d0,d7      ; B overflow
FIXOV      d5,d0,d7      ; A overflow
FIXOV      d6,d0,d7      ; B overflow
move.l     (sp)+,d7      ; restore count
bra        $ok

```

```

ENDFUNC

```

```

UV2RGB4SUB  FUNC      EXPORT

```

```

UV2RGB4     (a2)+,(a3)+      ; uv2rgb(*U++,*V++)
rts

```

```

ENDFUNC

```

```

FETCHY2SUB  FUNC      EXPORT

```

```

FETCHY2     (a0)+,d0,d1,d2,d3 ; add Ya to RGB values
FETCHY2     (a1)+,d0,d4,d5,d6 ; add Yb to RGB values
rts

```

```

ENDFUNC

```

```

if $TYPE('seg')='UNDEFINED' then

```

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Engineering: K11csCode.CompFast:Color3.a

```

      seq      &seq
    endif

YUV2RGB5     FUNC      EXPORT
.
PS          RECORD      3
Table       DS.L        1
pixmap      DS.L        1
Y           DS.L        1
U           DS.L        1
V           DS.L        1
area        DS.L        1
width       DS.L        1
cols        DS.L        1
            ENDR
.
LS          RECORD      0,DECR
inc         DS.L        1
width       DS.L        1
fend        DS.L        1
count       DS.L        1
row         DS.L        1
LSize       EQU         -
            ENDR
.
.      a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
.      d0..6 - used, d7 - count
.
      link      a6,LS.LSize      ; inc, width, fend and rowend are loca
      movem.l   d4-d7/a3-a5,-(a7) ; store registers
.
      move.l    PS.pixmap(a6),a4 ; pm0=pixmap
      move.l    a4,a5             ; pm1=pm0
      move.l    PS.Y(a6),a0        ; Y0=Yc
      move.l    a0,a1             ; Y1=Y0
      move.l    PS.U(a6),a2        ; U=Uc
      move.l    PS.V(a6),a3        ; V=Vc
      move.l    PS.area(a6),d7     ; fend=area
      lsl.l     #2,d7             ; fend<<=2
      add.l     a4,d7             ; fend+=pm0
      move.l    d7,LS.fend(a6)     ; save fend
      move.l    PS.width(a6),d5    ; width=width
      move.l    d5,d7             ; count=width
      asr.l     #1,d7             ; count>>=1
      subq.l    #1,d7             ; count-=1
      move.l    d7,PS.width(a6)    ; save width

      add.l     d5,d5             ; width*=2
      add.l     d5,a1             ; Y1+=width
      add.l     d5,d5             ; width*=2
      move.l    d5,LS.width(a6)    ; save width
      move.l    PS.cols(a6),d4     ; inc=cols
      lsl.l     #2,d4             ; inc<<=2
      move.l    d4,LS.row(a6)      ; *NEW save row
      add.l     d4,a5             ; pm1+=inc
      add.l     d4,a5             ; *NEW pm1+=inc
      add.l     d4,d4             ; cols*=2
      add.l     d4,d4             ; *NEW cols*=2
      sub.l     d5,d4             ; inc now 4*cols-width bytes
      sub.l     d5,d4             ; *NEW inc now 4*cols-width bytes (wid
      move.l    d4,LS.inc(a6)      ; save inc

9dc      move.l    d7,-(sp)

```

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Engineering: XilinxCode: CcmpPict: Color2.a

```

move.l    a6, -(sp)
move.l    LS.row(a6), d7
move.l    PS.Table(a6), a6
UV2RGB4    (a2)+, (a3)+          ; uv2rgb(*U--, *V--)

FETCHYC    (a0)+, d0, d1, d2, d3      ; add Ya to RGB values
FETCHYB    (a1)+, d0, d4, d5, d6      ; add Yb to RGB values

move.l    d1, d0
or.l      d2, d0
or.l      d3, d0
or.l      d4, d0
or.l      d5, d0
or.l      d6, d0
andi.l    #FFFFFF00, d0
bne.w     @over          ; if overflow

eck        MKRGB2    d1, d2, d3, a4, d7, d0 ; *NEW save RGBA
           MKRGB2    d4, d5, d6, a5, d7, d0 ; *NEW save RGBb
           move.l    (sp)+, a6
           move.l    (sp)+, d7

           dbf        d7, @do          ; while

           adda.l     LS.inc(a6), a4      ; pm0+=inc
           adda.l     LS.inc(a6), a5      ; pm1+=inc
           adda.l     LS.width(a6), a0    ; Y0+=width
           exg.l      a0, a1             ; Y1<->Y0
           move.l     PS.width(a6), d7    ; count=width
           cmpa.l     LS.fend(a6), a4     ; pm0<fend
           blt.s      @do                ; while

           mcven.l    (a7)+, d4-d7/a3-a5  ; restore registers
           unlk       a6                 ; remove locals
           rts        ; return
@over      move.l     d7, LS.count(a6)    ; save count
           clr.w      d7                 ; AND=0
           FIXOV      d1, d0, d7         ; A overflow
           FIXOV      d2, d0, d7         ; B overflow
           FIXOV      d3, d0, d7         ; A overflow
           FIXOV      d4, d0, d7         ; B overflow
           FIXOV      d5, d0, d7         ; A overflow
           FIXOV      d6, d0, d7         ; B overflow
           move.l     LS.count(a6), d7    ; restore count
           bra        @ok

           ENDFUNC
-----
           END

```

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Engineering:KLICSCode:CompFast:Clut.c

```

.....
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
.....;
**
    Analyse CLUT setup and pick appropriate
    YUV->RGB converter/display driver. Create
    any tables necessary.
*/

#include <QuickDraw.h>
#include <Memory.h>

#define Y_LEVELS    64
#define UV_LEVELS    16

#define abs(v) ((v)<0?-(v):(v))
#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr)=(type)NewPtr(size)) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr)=(type)NewPtr(size)) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

typedef struct {
    char    y, u, v;
} YUV_Clut;

/*
unsigned char *
ColourClut(CTabHandle clut)
{
    int    size, y, u, v, r, g, b, i;
    unsigned char *table;
    YUV_Clut    *yuv_clut;

    size=(clut)->ctSize;
    table=(unsigned char *)NewPtr(Y_LEVELS*UV_LEVELS*UV_LEVELS);
    yuv_clut=(YUV_Clut *)NewPtr(size*sizeof(YUV_Clut));

    for(i=0;i<size;i++) {
        r=((clut)->ctTable[i].rgb.red>>8)-128;
        g=((clut)->ctTable[i].rgb.green>>8)-128;
        b=((clut)->ctTable[i].rgb.blue>>8)-128;

        yuv_clut[i].y= (306*r + 601*g + 117*b)>>10;
        yuv_clut[i].u= (512*r - 429*g - 83*b)>>10;
        yuv_clut[i].v= (-173*r - 339*g + 512*b)>>10;
    }
    for(y=Y_LEVELS/2;y<Y_LEVELS/2-1;y++)
    for(u=UV_LEVELS/2;u<UV_LEVELS/2-1;u++)
    for(v=UV_LEVELS/2;v<UV_LEVELS/2-1;v++) {
        int    index,error,error2,points, Y, U, V;

```



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Engineering:KlicsCode:CompPict:Clut.c

```

Y=y<<4;
U=u<<5;
V=v<<5;

index=0;
error=131072;
error2=131072;
points=0;
for(i=0;i<=size;i++) {
    int pts=0, err=0;

    if (yuv_clut[i].y>=Y && yuv_clut[i].y<Y+16)
        pts+=1;
    err+=absv(yuv_clut[i].y-Y);

    if (yuv_clut[i].u>=U && yuv_clut[i].u<U+32)
        pts+=1;
    err+=absv(yuv_clut[i].u-U);

    if (yuv_clut[i].v>=V && yuv_clut[i].v<V+32)
        pts+=1;
    err+=absv(yuv_clut[i].v-V);

    if (pts>points || (pts==points && err<error)) {
        error=err;
        index=i;
        points=pts;
    }
}
i=((y<<0xF)<<8)|((u<<0xF)<<4)|(v<<0xF);
table[i]=(unsigned char)index;
}
DisposePtr((Ptr)yuv_clut);
return table;
}

typedef union {
    long pixel;
    unsigned char rgb[4];
} Pixel;

/*
unsigned long *
ColourClut(CTabHandle clut)
{
    long size, y, u, v, r, g, b, ro, go, bo, i;
    Pixel *table;

    size=(*clut)->ctSize;
    table=(Pixel *)NewPtr(Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(long));

    for(y=-Y_LEVELS/2;y<Y_LEVELS/2-1;y++)
    for(u=-UV_LEVELS/2;u<UV_LEVELS/2-1;u++)
    for(v=-UV_LEVELS/2;v<UV_LEVELS/2-1;v++) {
        Pixel px;
        long base, dith;

        r = 32768L + ((y<<9) + 1436L*u <<2);
        g = 32768L + ((y<<9) - 711L*u - 352L*v <<2);
        b = 32768L + ((y<<9) + 1815L*v <<2);

        r=r<0?0:r>65534?65534:r;
        g=g<0?0:g>65534?65534:g;
        b=b<0?0:b>65534?65534:b;
    }
}

```

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Engineering:KlacsCode:CompPict:Clut.c

```

    rc=r/13107; r=r/13107;
    gc=g/13107; g=g/13107;
    bc=b/13107; b=b/13107;

    base=215-(35*r-6*g-b);

    dith=base-(ro>2621736:0)-(gc>786376:0)-(bo>1048471:0);
    px.rgb[0]=dith==215?255:dith;

    dith=base-(ro>5242736:0)-(gc>1048476:0)-(bo>262171:0);
    px.rgb[1]=dith==215?255:dith;

    dith=base-(ro>7863736:0)-(gc>262176:0)-(bo>524271:0);
    px.rgb[2]=dith==215?255:dith;

    dith=base-(ro>10484736:0)-(gc>524276:0)-(bo>786371:0);
    px.rgb[3]=dith==215?255:dith;

    i=((y&0x3F)<<8)|((u&0xF)<<4)|(v&0xF);

    table[i].pixel=px.pixel;
}
return (unsigned long*)table;
}

typedef struct {
    long    red, green, blue;
} RGBError;

OSErr ColourClut(Pixel **table)
{
    long    y, u, v, r, g, b, i;
    RGBError *err;
    THz     saveZone;

    NewPointer(*table, Pixel*, Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(long)); /* 64k ta
    NewPointer(err, RGBError*, Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(RGBError));

    for(i=0; i<4; i++)
        for(y=-Y_LEVELS/2; y<Y_LEVELS/2; y++)
            for(u=-UV_LEVELS/2; u<UV_LEVELS/2; u++)
                for(v=-UV_LEVELS/2; v<UV_LEVELS/2; v++) {
                    RGBColor    src, dst;
                    long    index, in;

                    index=((y&0x3F)<<8)|((u&0xF)<<4)|(v&0xF);

                    r = 32768L + ((y<<9) + (1436L*u) <<2);
                    g = 32768L + ((y<<9) - (731L*u) - (352L*v) <<2);
                    b = 32768L + ((y<<9) + (1815L*v) <<2);

                    if (i>0) {
                        r--err[index].red;
                        g--err[index].green;
                        b--err[index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    (*table)[index].rgb[i]= (unsigned char)Color2Index(4src);
                }
            }
        }
    }

```

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➤ Engineering:KlacsCode:CompPict:Cluc.c

```

Index2Color((*table)[index].rgb[i], &dst);
err[index].red=dst.red-src.red;
err[index].green=dst.green-src.green;
err[index].blue=dst.blue-src.blue;
}
DisposePtr((Ptr)err);
return(noErr);
}

typedef struct {
    short    pel[2];
} Pix16;

typedef struct {
    unsigned char    pel[4];
} Pix8;

#define YS 64
#define UVS 32

OSErr Colour8(Pix8 **table)
{
    long    y, u, v, r, g, b, i;
    RGBError    *err;
    THz    saveZone;

    NewPointer(*table, Pix8*YS*UVS*UVS*sizeof(Pix8)); /* 128k table */
    NewPointer(err, RGBError*YS*UVS*UVS*sizeof(RGBError));

    for(i=0; i<4; i++)
        for(y=-YS/2; y<YS/2; y++)
            for(u=-UVS/2; u<UVS/2; u++)
                for(v=-UVS/2; v<UVS/2; v++) {
                    RGBColor    src, dst;
                    long    index;

                    index=(y<<10)|((u<0?1F)<<5)|((v<0?1F));

                    r = 32768L - ((y<<10) - (1436L*u) <<1);
                    g = 32768L - ((y<<10) - (731L*u) - (352L*v) <<1);
                    b = 32768L - ((y<<10) - (1815L*v) <<1);

                    if (i>0) {
                        r+=err[32768+index].red;
                        g+=err[32768+index].green;
                        b+=err[32768+index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    (*table)[32768+index].pel[i]=(unsigned char)Color2Index(&src);
                    Index2Color((*table)[32768+index].pel[i], &dst);

                    err[32768+index].red=dst.red-src.red;
                    err[32768+index].green=dst.green-src.green;
                    err[32768+index].blue=dst.blue-src.blue;
                }
    DisposePtr((Ptr)err);
    return(noErr);
}

```

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Engineering: XilinxCode: CompPict: Clut.c

```

OSErr Colour16(Pix16 **table)
{
    long    y, u, v, s, g, b, i;
    RGBError *err;
    TH:      saveZone;

    NewPointer((table, Pix16*, YS*UVS*UVS*sizeof(Pix16)), /* 128k table */
    NewPointer(err, RGBError*, YS*UVS*UVS*sizeof(RGBError));

    for(i=0; i<2; i++)
        for(y=-YS/2; y<YS/2; y++)
            for(u=-UVS/2; u<UVS/2; u++)
                for(v=-UVS/2; v<UVS/2; v++) {
                    RGBColor src, dst;
                    long index;

                    index = (y<<10) | ((u<0?1F)<<5) | (v<0?1F);

                    r = 32768L - ((y<<10) + (1436L*u) <<1);
                    g = 32768L - ((y<<10) - (731L*u) - (352L*v) <<1);
                    b = 32768L - ((y<<10) + (1915L*v) <<1);

                    if (i>0) {
                        r=err[32768+index].red;
                        g=err[32768+index].green;
                        b=err[32768+index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    dst.red= src.red&0xF800;
                    dst.green= src.green&0xF800;
                    dst.blue= src.blue&0xF800;

                    (*table)[32768+index].pel[i] = (dst.red>>1) | (dst.green>>6) | (dst.blue>>11);

                    err[32768+index].red=dst.red-src.red;
                    err[32768+index].green=dst.green-src.green;
                    err[32768+index].blue=dst.blue-src.blue;
                }
    DisposePtr((Ptr)err);
    return(noErr);
}

Boolean
GreyClut(CTabHandle clut)
{
    Boolean result=true;
    int i, size;

    size=(*clut)->ctSize;
    for(i=0; i<size && result; i++) {
        int r, g, b;

        r=(*clut)->ctTable[i].rgb.red;
        g=(*clut)->ctTable[i].rgb.green;
        b=(*clut)->ctTable[i].rgb.blue;

        result=(r==g && g==b);
    }
}

```

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Engineering:KlicsCode:CompPic:Clut.c

return result;

Engineering:KLICSCode:CompPict:Bits3.h

```

.....
.
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.
.  Written by: Adrian Lewis
.
...../
/*
  Bits3.h: fast bit read/write definitions

  buf_use      define static variables
  buf_winit    initialise vars for write
  buf_rinit    initialise vars for read
  buf_set      set current bit
  buf_get      get current bit
  buf_winc     increment write buffer
  buf_rinc     increment read buffer
  buf_size     fullness of buffer in bytes
  buf_flush    flush buffer

  User defined macro/function buf_over must be defined in case of buffer overflow
..

typedef struct {
    unsigned long  *buf;
    union {
        unsigned long  mask;
        long           bno;
    } index;
    unsigned long  *ptr, data, size;
} Buffer, *Buf;

#define buf_winit(buf) \
    buf->index.mask=0x80000000; \
    buf->ptr=&buf->buf(0); \
    buf->data=0;

#define buf_rinit(buf) \
    buf->index.bno=0; \
    buf->ptr=&buf->buf(0);

#define buf_set(buf) \
    buf->data |= buf->index.mask;

#define buf_get(buf) \
    0:=(buf->data & (1<<buf->index.bno) )

#define buf_winc(buf) \
    if (buf->index.mask==1) { \
        *buf->ptr=buf->data; \
        buf->data=0; \
        buf->index.mask=0x80000000; \
        buf->ptr++; \
    } else buf->index.mask >>= 1;

#define buf_rinc(buf) \
    if (--(buf->index.bno)<0) { \
        buf->data=*buf->ptr++; \
        buf->index.bno=31; \
    };

/* buf_size only valid after buf_flush */

```

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Engineering:Kl:csCode:CompPict:Bits3.h

```
•define buf_size(buf) \
(unsigned char *)buf->ptr-(unsigned char *)&buf->buf[0]

•define buf_flush(buf) \
if (buf->index.mask!=0x80000000) { \
    buf->data|=buf->index.mask-1; \
    *buf->ptr=buf->data; \
    buf->ptr++; \
}
```

Engineering:KLICSCode:CompPict:Bits3.e

```

-----
.
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.
.  Written by: Adrian Lewis
.
-----
.
.  63000 Bit buffer code (Bits2.h)
.
-----
.
.  Macros:
.    buf_winit    &ptr, &data, &mask, &buf
.    buf_rinit    &ptr, &bno, &buf
.    buf_set      &data, &mask
.    buf_get      &data, &bno
.    buf_winc     &ptr, &data, &mask
.    buf_rinc     &ptr, &data, &index
.    buf_flush    &ptr, &data, &mask
.
-----
.
.    macro
.    buf_winit    &ptr, &data, &mask, &buf
.
.    move.l      $580000000, &mask      ; mask=100...
.    move.l      &buf, &ptr             ; ptr=buf
.    clr.l       &data                  ; data=0
.
.    endm
.
-----
.
.    macro
.    buf_rinit    &ptr, &bno, &buf
.
.    clr.b       &bno                   ; bno=0
.    move.l      &buf, &ptr             ; ptr=buf
.
.    endm
.
-----
.
.    macro
.    buf_set      &data, &mask
.
.    clr.l       &mask, &data          ; data := mask
.
.    endm
.
-----
.
.    macro
.    buf_get      &data, &bno
.
.    subq.b      #1, &bno
.    bsr         &bno, &data
.
.    endm
.
-----
.
.    macro
.    buf_winc     &ptr, &data, &mask
.
.    lsr.l       #1, &mask              ; mask>>=1
.    bne.s       @cont                  ; if non-zero continue
.    move.l      &data, (&ptr)+        ; *ptr++=data
.    clr.l       &data                  ; data=0
.    move.l      $580000000, &mask     ; mask=100...

```



- 777 -

Engineering:K11csCode:CompPict:3115}.a

```

?cont
.
    endm
-----
macro
buf_rinc    iptr,&data,&bno

    cmpi.b    #16,&bno
    bge.s    ?cont
    swap      &data
    move.w    (&ptr)+,&data        ; data=*ptr++
    add.b    #16,&bno                ; bno+=16

@cont
.
    endm
-----
macro
buf_flush    &ptr,&data,&mask

    cmp.l    #0,&mask                ; mask=00000000?
    beq.s    ?cont                    ; if buffer empty continue
    move.l    &data,(&ptr)+          ; *ptr++=&data

    endm
-----

```

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Engineering:KLICSCode:CompPict:Backward.c

```

.....
*
*  © Copyright: 1993 KLICS Limited
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*
*  Written by: Adrian Lewis
*
...../
/*
  Extra fast Backward\convolver
  New wavelet coeffs : 1 5 1 1. 1 2 1. 1 1

  Optimized for speed:
    diin - False
    src/dst octave == 0
*/

#define BwdS0(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG=-v; \
    dAH=v; \
    dBH=v<<1; \

#define BwdS1(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH=v>>1; \
    dAG=v-(v<<1); \
    dAH=v-(v<<1); \
    *(short *)addr0=dBH>>1; \

#define Bwd2(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG=-v; \
    dBH=v; \
    dAH=v-(v<<1); \
    dAG=v-(v<<1); \

#define Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH=v; \
    dAG=v; \
    dBG=v-(v<<1); \
    dBH=v-(v<<1); \
    *(short *)addr1=(dAH-1)>>2; \
    *(short *)addr2=(dAG-1)>>2; \

#define Bwd0(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG=-v; \
    dAH=v; \
    dBH=v-(v<<1); \
    dBG=v-(v<<1); \

#define Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBH=v; \
    dBG=v; \
    dAG=v-(v<<1); \
    dAH=v-(v<<1); \
    *(short *)addr3=(dBH-1)>>2; \
    *(short *)addr0=(dBG-1)>>2; \

#define BwdE2(addr2,dAG,dAH,dBH) \

```

- 779 -

Engineering:KilcsCode:CompPict:Backward.c

```

v=*(short *)addr2; \
dBH= v>>1; \
DAH= v-(v>>1); \
dAG= v-(v>>1);

#define BwdE3(addr3,addr2,addr1,dAG,DAH,dBH) \
v=*(short *)addr3; \
DAH= v; \
dAG= v; \
dBH= v-(v>>1); \
dBH= v-(v>>1); \
*(short *)addr1=(DAH+1)>>2; \
*(short *)addr2=(dAG+1)>>2; \
*(short *)addr3=dBH>>1;

#define Bwd(base,end,inc) \
addr0=base; \
addr3=addr0-(inc>>2); \
addr2=addr3-(inc>>2); \
addr1=addr2-(inc>>2); \
BwdS0(addr0,dAG,DAH,dBH); \
addr1+=inc; \
BwdS1(addr1,addr0,dAG,DAH,dBH); \
addr2+=inc; \
while(addr2<end) { \
    Bwd2(addr2,dAG,DAH,dBG,dBH); \
    addr3+=inc; \
    Bwd3(addr3,addr2,addr1,dAG,DAH,dBG,dBH); \
    addr0+=inc; \
    Bwd0(addr0,dAG,DAH,dBG,dBH); \
    addr1+=inc; \
    Bwd1(addr1,addr0,addr3,dAG,DAH,dBG,dBH); \
    addr2+=inc; \
} \
BwdE2(addr2,dAG,DAH,dBH); \
addr3+=inc; \
BwdE3(addr3,addr2,addr1,dAG,DAH,dBH);

#define BwdS0r2(addr0,dAG,DAH,dBH) \
v=*(short *)addr0; \
dAG= 0; \
DAH= v; \
dBH= v; \

#define BwdS1r2(addr1,addr0,dAG,DAH,dBH) \
v=*(short *)addr1; \
dBH= v>>2; \
dAG= v; \
DAH= v<<1; \
*(short *)addr0=dBH;

#define Bwd2r2(addr2,dAG,DAH,dBG,dBH) \
v=*(short *)addr2; \
dBG= 0; \
dBH= v; \
DAH= v; \
dAG= v<<1;

#define Bwd3r2(addr3,addr2,addr1,dAG,DAH,dBG,dBH) \
v=*(short *)addr3; \
DAH= 0; \
dAG= v; \
dBG= v; \

```

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Engineering:MicroCode:CompFct:Backward.c

```

    DBH-= v<<1; \
    *(short *)addr1=dAH>>1; \
    *(short *)addr2=dAG>>1;

#define Bwd0r2(addr0,dAG,dAH,dBG,DBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= v; \
    DBH-= v; \
    DBG-= v<<1;

#define Bwd1r2(addr1,addr0,addr3,dAG,dAH,dBG,DBH) \
    v=(short *)addr1; \
    DBH-= 0; \
    DBG-= v; \
    dAG+= v; \
    dAH-= v<<1; \
    *(short *)addr3=DBH>>1; \
    *(short *)addr0=DBG>>1;

#define BwdE2r2(addr2,dAG,dAH,DBH) \
    v=(short *)addr2; \
    DBH= v; \
    dAH+= v; \
    dAG+= v<<1;

#define BwdE3r2(addr3,addr2,addr1,dAG,dAH,DBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= v; \
    DBH-= v; \
    DBH-= v<<1; \
    *(short *)addr1=dAH>>1; \
    *(short *)addr2=dAG>>1; \
    *(short *)addr3=DBH;

#define Bwdr2(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0r2(addr0,dAG,dAH,DBH); \
    addr1+=inc; \
    BwdS1r2(addr1,addr0,dAG,dAH,DBH); \
    addr2+=inc; \
    while(addr2<end) { \
        Bwd2r2(addr2,dAG,dAH,dBG,DBH); \
        addr3+=inc; \
        Bwd3r2(addr3,addr2,addr1,dAG,dAH,dBG,DBH); \
        addr0+=inc; \
        Bwd0r2(addr0,dAG,dAH,dBG,DBH); \
        addr1+=inc; \
        Bwd1r2(addr1,addr0,addr3,dAG,dAH,dBG,DBH); \
        addr2+=inc; \
    } \
    BwdE2r2(addr2,dAG,dAH,DBH); \
    addr3+=inc; \
    BwdE3r2(addr3,addr2,addr1,dAG,dAH,DBH);

#define BwdS0r3(addr0,dAG,dAH,DBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= 0; \

```

Engineering:KlicsCode:CompFct:Backward.c

```

    dBH= v>>1; \

#define Bwd5r3(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH= v>>1; \
    dAG+= v; \
    dAH+= v; \
    *(short *)addr0=dBH<<1;

#define Bwd2r3(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG= 0; \
    dBH= 0; \
    dAH+= v; \
    dAG+= v;

#define Bwd3r3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= 0; \
    dBG+= v; \
    dBH+= v; \
    *(short *)addr1=dAH; \
    *(short *)addr2=dAG;

#define Bwd0r3(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= 0; \
    dBH+= v; \
    dBG+= v;

#define Bwd1r3(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBH+= 0; \
    dBG+= 0; \
    dAG+= v; \
    dAH+= v; \
    *(short *)addr3=dBH; \
    *(short *)addr0=dBG;

#define BwdE2r3(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    dBH= v>>1; \
    dAH+= v; \
    dAG+= v;

#define BwdE3r3(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= 0; \
    dBH+= v; \
    dBH+= v; \
    *(short *)addr1=dAH; \
    *(short *)addr2=dAG; \
    *(short *)addr3=dBH<<1;

#define Bwdr3(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    Bwd5r3(addr0,dAG,dAH,dBH); \

```

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Engineering:KlitsCode:CompFict:Backward.c

```

addr1+=inc; \
BwdS1r3(addr1,addr0,dAG,dAH,dBH); \
addr2+=inc; \
while(addr2<end1) { \
    Bwd2r3(addr2,dAG,dAH,dBG,dBH); \
    addr3+=inc; \
    Bwd3r3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
    addr0+=inc; \
    Bwd0r3(addr0,dAG,dAH,dBG,dBH); \
    addr1+=inc; \
    Bwd1r3(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
    addr2+=inc; \
} \
BwdE2r3(addr2,dAG,dAH,dBH); \
addr3+=inc; \
BwdE3r3(addr3,addr2,addr1,dAG,dAH,dBH);

extern void FASTBACKWARD(char *data, long incl, long loop1, long inc2, char *end2)
extern void HAARBACKWARD(char *data, long incl, long loop1, long inc2, long loop2)
extern void HAARTOPBWD(char *data, long height, long width);
/* extern void HAARXTOPBWD(char *data, long area); */

void FasterBackward(char *data, long incl, long end1, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, dBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data; base<end2; base+=inc2) {
        end=base+end1;
        Bwd(base, end, inc);
    }
}

extern void TOPBWD(char *data, char *dst, long size_1, long size_0);

void TestTopBackward(short *data, int size(2), int oct_src)
{
    int oct, area=size(0)*size(1)<<1;
    short width=size(0)<<1;
    char *top=area-(char *)data, *left=width-(char *)data;

    for(oct=oct_src-1; oct>0; oct--) {
        long cinc=2<<oct, cinc4=cinc<<2,
            rinc=size(0)<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data, rinc4, area-(rinc<<1), cinc, left);
        FASTBACKWARD((char *)data, cinc4, width-(cinc<<1), rinc, top);
    }
    /* FasterBackward((char *)data, size(0)<<3, area-(size(0)<<2), 2, left);
    FasterBackward((char *)data, 8, width-4, size(0)<<1, top); */
    TOPBWD((char *)data, (char *)data, size(0), size(1));
}

void TestBackward(data, size, oct_src)
short *data;
int size(2), oct_src;

{
    int oct, area=size(0)*size(1)<<1;
    short width=size(0)<<1;
    char *top=area-(char *)data, *left=width-(char *)data;

```

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Engineering:KillsCode:CompPact:Backward.c

```

for(oct=oct_src-1;oct>0;oct--) {
    long    cinc=2<<oct, cinc4=cinc<<2,
            rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

    FasterBackward((char *)data,rinc4,area-(rinc<<1),cinc,left);
    FasterBackward((char *)data,cinc4,width-(cinc<<1),rinc,top);
}

void    Backward3511(data,size,oct_src)
short    *data;
int    size[2], oct_src;

{
    int    oct, area=size[0]*size[1]<<1;
    short    width=size[0]<<1;
    char    *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>0;oct--) {
        long    cinc=2<<oct, cinc4=cinc<<2,
                rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        BACK3511((char *)data,rinc4,area-(rinc<<1),cinc,left);
        BACK3511((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
    BACK3511V((char *)data,size[0]<<3,area-(size[0]<<2),4,left);
    BACK3511H((char *)data,8,width-4,size[0]<<1,top);
    /* TOPBWD((char *)data,(char *)data,size[1],size[0]); */
}

```

Engineering:KlicsCode:CompFict:Backward.a

```

-----
.
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.
.  Written by: Adrian Lewis
.
-----
.
.  680X0 3511 Backward code
.
.  Coeffs 11 19 5 3
.  become 3 5 1 1
.
-----
.
.  seg      'klics'
.
-----
.
.  macro
.  BwdStart0    &addr0,&dAG,&dAH,&dBH
.
.  move.w      (&addr0),&dAH    ; dAH=(short *)addr0
.  move.w      &dAH,&dAG        ; dAG=v
.  neg.w       &dAG             ; dAG=-dAG
.  move.w      &dAH,&dBH        ; dBH=v
.  add.w       &dBH,&dBH        ; dBH=v<<1
.
.  endm
.
-----
.
.  macro
.  BwdStart1    &addr1,&addr0,&dAG,&dAH,&dBH
.
.  move.w      (&addr1),d0      ; v=(short *)addr1
.  move.w      d0,d1            ; v=v
.  asr.w       #1,d1            ; v=v>>1
.  add.w       d1,&dBH          ; dBH=v v>>1
.  add.w       d0,&dAG          ; dAG=v
.  sub.w       d0,&dAH          ; dAH=-v
.  add.w       d0,d0            ; v<<1
.  add.w       d0,&dAG          ; dAG=-2v
.  add.w       d0,d0            ; v<<1
.  sub.w       d0,&dAH          ; dAH=-4v
.  asr.w       #1,&dBH          ; dBH>>1
.  move.w      &dBH,(&addr0)    ; *(short *)addr0=dBH
.
.  endm
.
-----
.
.  macro
.  BwdEven &addr2,&dAG,&dAH,&DBG,&dBH
.
.  move.w      (&addr2),d0      ; v=(short *)addr2
.  move.w      d0,&dBH          ; dBH=v
.  move.w      d0,&DBG          ; DBG=v
.  neg.w       &DBG             ; DBG=-v
.  add.w       d0,&dAH          ; dAH=v
.  add.w       d0,&dAG          ; dAG=v
.  add.w       d0,d0            ; 2v
.  add.w       d0,&dAH          ; dAH=v
.  add.w       d0,d0            ; 2v
.  add.w       d0,&dAG          ; dAH=v
.
.  endm
.
-----
.
.  macro

```



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Engineering:KlacsCode:CompPict:Backward.a

```

BwdOdd      (&addr3),(&addr2),(&addr1),(&dAG),(&dAH),(&DBG),(&DBH)

```

```

move.w      (&addr3),d0      ; v=*(short *)addr3

```

```

add.w       d0,&dAH           ; dAH+=v

```

```

add.w       d0,&dAG           ; dAG+=v

```

```

add.w       d0,&DBG           ; DBG+=v

```

```

sub.w       d0,&DBH           ; DBH-=v

```

```

add.w       d0,d0             ; 2v

```

```

add.w       d0,&DBG           ; DBG+=v

```

```

add.w       d0,d0             ; 4v

```

```

sub.w       d0,&DBH           ; DBH-=4v

```

```

asr.w       #2,&dAH           ; dAH>>=2

```

```

move.w      &dAH,(&addr1)     ; *(short *)addr1=dAH

```

```

asr.w       #2,&dAG           ; dAG>>=2

```

```

move.w      &dAG,(&addr2)     ; *(short *)addr2=dAG

```

```

endm

```

```

macro
Bwd2nd2      (&addr2),(&dAG),(&dAH),(&DBH)

```

```

move.w      (&addr2),d0      ; v=*(short *)addr2

```

```

add.w       d0,&dAH           ; dAH+=v

```

```

add.w       d0,&dAG           ; dAG+=v

```

```

add.w       d0,d0             ; 2v

```

```

move.w      d0,&DBH           ; DBH=2v

```

```

add.w       d0,&dAH           ; dAH+=2v

```

```

add.w       d0,d0             ; 4v

```

```

add.w       d0,&dAG           ; dAG+=4v

```

```

endm

```

```

macro
Bwd2nd3      (&addr3),(&addr2),(&addr1),(&dAG),(&dAH),(&DBH)

```

```

move.w      (&addr3),d0      ; v=*(short *)addr3

```

```

add.w       d0,&dAH           ; dAH+=v

```

```

add.w       d0,&dAG           ; dAG+=v

```

```

lsl.w       #3,d0            ; 8v

```

```

sub.w       d0,&DBH           ; DBH-=8v

```

```

asr.w       #2,&dAH           ; dAH>>=2

```

```

move.w      &dAH,(&addr1)     ; *(short *)addr1=dAH

```

```

asr.w       #2,&dAG           ; dAG>>=2

```

```

move.w      &dAG,(&addr2)     ; *(short *)addr2=dAG

```

```

asr.w       #1,&DBH           ; DBH>>=1

```

```

move.w      &DBH,(&addr3)     ; *(short *)addr3=DBH

```

```

endm

```

```

macro
Bwd          (&base,&end,&inc)

```

```

movea.l     &base,a0          ; addr0=base

```

```

move.l      &inc,d0           ; d0=inc

```

```

asr.l       #2,d0             ; d0=inc>>2

```

```

movea.l     a0,a3             ; addr3=addr0

```

```

suba.l      d0,a3             ; addr3-=inc>>2

```

```

movea.l     a3,a2             ; addr2=addr3

```

```

suba.l      d0,a2             ; addr2-=inc>>2

```

```

movea.l     a2,a1             ; addr1=addr2

```

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Engineering:KlicsCode:CompPict:Backward.a

```

suba.l    d0,a1                ; addr1+=(inc>>2)
BwdStart0 a0,d4,d5,d7          ; BwdStart0(addr0,dAG,dAH,dBH)
adda.l    4,inc,a1              ; addr1+=inc
BwdStart1 a1,a0,d4,d5,d7        ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l    4,inc,a2              ; addr2+=inc
?do       BwdEven a2,d4,d5,d6,d7 ; BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l    4,inc,a3              ; addr3+=inc
BwdOdd    a3,a2,a1,d4,d5,d6,d7 ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l    4,inc,a0              ; addr0+=inc
BwdEven   a0,d6,d7,d4,d5        ; BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l    4,inc,a1              ; addr1+=inc
BwdOdd    a1,a0,a3,d6,d7,d4,d5 ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l    4,inc,a2              ; addr2+=inc
cmpa.l    0,6,end               ; addr2<end
bgt.s     0dc                   ; while
BwdEnd2   a2,d4,d5,d7           ; BwdEnd2(addr2,dAG,dAH,dBH)
adda.l    4,inc,a3              ; addr3+=inc
BwdEnd3   a3,a2,a1,d4,d5,d7     ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB

```

endm

-----  
Back3511 FUNC EXPORT

```

PS        RECORD      8
data      DS.L         1
inc1      DS.L         1
end1      DS.L         1
inc2      DS.L         1
end2      DS.L         1
          ENDR

          link          a6,#0          ; no local variables
          movem.l       d4-d7/a3-a5,-(a7) ; store registers

          move.l        PS,inc1(a6),d3  ; inc=inc1
          movea.l       PS,data(a6),a5  ; base=data
?do       movea.l       a5,a4           ; end=base
          adda.l        PS,end1(a6),a4  ; end=end1
          Bwd           a5,a4,d3         ; Bwd(base,end,inc)
          adda.l        PS,inc2(a6),a5  ; base+=inc2
          cmpa.l        PS,end2(a6),a5  ; end2>base
          blt.w         0do             ; for

          movem.l       (a7)+,d4-d7/a3-a5 ; restore registers
          unlk          a6              ; remove locals
          rts              ; return

```

ENDFUNC

-----  
macro  
BwdStartV0 4addr0,&dAG,&dAH,&dBH

```

          move.l        (4addr0),&dAH  ; dAH=(short *)addr0
          move.l        &dAH,&dAG       ; dAG=v
          neg.l         &dAG           ; dAG=-dAG
          move.l        &dAH,&dBH       ; dBH=v
          add.l         &dBH,&dBH       ; dBH=v<<1

```

endm

-----  
macro  
BwdStartV1 4addr1,&addr0,&dAG,&dAH,&dBH

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=Engineering:KilicsCode:CompPict:Backward.a

```

move.l    (&addr1).d0      : v=*(short *)addr1
move.l    d0,d1            : v=v
asr.l     #1,d1            : v=v>>1
add.l     d1,&dBH          : dBH+=v>>1
add.l     d0,&dAG          : dAG+=v
sub.l     d0,&dAH          : dAH-=v
add.l     d0,d0            : v<<=1
add.l     d0,&dAG          : dAG+=2v
add.l     d0,d0            : v<<=1
sub.l     d0,&dAH          : dAH-=4v

asr.l     #1,&dBH          : dBH>>=1
add.w     &dBH,&dBH        : shift word back
asr.w     #1,&dBH          : dBH>>=1
move.l    &dBH,(&addr0)   : *(short *)addr0=dBH

```

```

endm
-----

```

```

macro
BwdEvenV    &addr2,&dAG,&dAH,&DBG,&dBH

```

```

move.l    (&addr2).d0      : v=*(short *)addr2
move.l    d0,&dBH          : dBH=v
move.l    d0,&DBG          : DBG=v
neg.l     &DBG             : DBG=-v
add.l     d0,&dAH          : dAH+=v
add.l     d0,&dAG          : dAG+=v
add.l     d0,d0            : 2v
add.l     d0,&dAH          : dAH+=v
add.l     d0,d0            : 2v
add.l     d0,&dAG          : dAG+=v

```

```

endm
-----

```

```

macro
BwdOddV     &addr3,&addr2,&addr1,&dAG,&dAH,&DBG,&dBH

```

```

move.l    (&addr3).d0      : v=*(short *)addr3

add.l     d0,&dAH          : dAH+=v
add.l     d0,&dAG          : dAG+=v
add.l     d0,&DBG          : DBG+=v
sub.l     d0,&dBH          : dBH-=v
add.l     d0,d0            : 2v
add.l     d0,&DBG          : DBG+=v
add.l     d0,d0            : 4v
sub.l     d0,&dBH          : dBH-=4v

asr.l     #2,&dAH          : dAH>>=2
lsl.w     #2,&dAH          : shift word back
asr.w     #2,&dAH          : dAH>>=2
move.l    &dAH,(&addr1)    : *(short *)addr1=dAH
asr.l     #2,&dAG          : dAG>>=2
lsl.w     #2,&dAG          : shift word back
asr.w     #2,&dAG          : dAG>>=2
move.l    &dAG,(&addr2)    : *(short *)addr2=dAG

```

```

endm
-----

```

```

macro
BwdEndV2    &addr2,&dAG,&dAH,&dBH

```

```

move.l    (&addr2).d0      : v=*(short *)addr2

```

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Engineering:KlitsCode:CompPict:Backward.a

```

add.l    d0,&dAH      : dAH+=v
add.l    d0,&dAG      : dAG+=v
add.l    d0,d0        : 2v
move.l    d0,&dBH      : dBH=2v
add.l    d0,&dAH      : dAH+=2v
add.l    c0,d0        : 4v
add.l    d0,&dAG      : dAG+=4v

```

endm

-----

macro

```

BwdEndV3    &addr3,&addr2,&addr1,&dAG,&dAH,&dBH

move.l    (&addr3),d0    : v=(short *)addr3
add.l    d0,&dAH          : dAH+=v
add.l    d0,&dAG          : dAG+=v
lsl.l    #3,d0           : 8v
sub.l    d0,&dBH          : dBH-=8v
asr.l    #2,&dAH          : dAH>>=2
lsl.w    #2,&dAH          : shift word back
asr.w    #2,&dAH          : dAH>>=2
move.l    &dAH,(&addr1)   : *(short *)addr1=dAH
asr.l    #2,&dAG          : dAG>>=2
lsl.w    #2,&dAG          : shift word back
asr.w    #2,&dAG          : dAG>>=2
move.l    &dAG,(&addr2)   : *(short *)addr2=dAG
asr.l    #1,&dBH          : dBH>>=1
lsl.w    #1,&dBH          : shift word back
asr.w    #1,&dBH          : dBH>>=1
add.l    &dBH,&dBH        : dBH<<=1
move.l    &dBH,(&addr3)  : *(short *)addr3=dBH

```

endm

-----

macro

```

BwdV        &base,&end,&inc

movea.l    &base,a0      : addr0=base
move.l     &inc,d0        : d0=inc
asr.l      #2,d0         : d0=inc>>2
movea.l    a0,a3         : addr3=addr0
suba.l     d0,a3         : addr3-=inc>>2
movea.l    a3,a2         : addr2=addr3
suba.l     d0,a2         : addr2-=inc>>2
movea.l    a2,a1         : addr1=addr2
suba.l     d0,a1         : addr1-=inc>>2
BwdStartV0 a0,d4,d5,d7   : BwdStart0(addr0,dAG,dAH,dBH)
adda.l     &inc,a1        : addr1+=inc
BwdStartV1 a1,a0,d4,d5,d7 : BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l     &inc,a2        : addr2+=inc
9do BwdEvenV a2,d4,d5,d6,d7 : BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l     &inc,a3        : addr3+=inc
BwdOddV    a3,a2,a1,d4,d5,d6,d7 : BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l     &inc,a0        : addr0+=inc
BwdEvenV    a0,d6,d7,d4,d5 : BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l     &inc,a1        : addr1+=inc
BwdOddV    a1,a0,a3,d6,d7,d4,d5 : BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l     &inc,a2        : addr2+=inc
cmpa.l     a2,&end        : addr2<end
bgt.s      9do           : while
BwdEndV2    a2,d4,d5,d7   : BwdEnd2(addr2,dAG,dAH,dBH)
adda.l     &inc,a3        : addr3+=inc

```

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Engineering:KlicsCode:CompPic:Backward.a

```

EwdEndV3      a3,a2,a1,d4,d5,d7      : EwdEnd3(addr),addr2,addr1,dAG,dAH,dB

-----
enclm
BackJ511V     FUNC      EXPORT
PS            RECCRC      6
data          DS.L        1
incl          DS.L        1
endi          DS.L        1
inc2          DS.L        1
end2          DS.L        1
ENDR

link          a6,40          : no local variables
movem.l       c4-d7/a3-a5,-(a7)    : store registers

move.l        PS.incl(a6),d3      : inc=incl
movea.l       PS.data(a6),a5      : base=data
3do           movea.l       a5,a4      : end=base
adda.l        PS.end1(a6),a4      : end+=end1
BwdV          a5,a4,d3            : Bwd(base,end,inc)
adda.l        PS.inc2(a6),a5      : base+=inc2
cmpa.l        PS.end2(a6),a5      : end2>base
bit.w         0do                : for

movem.l       (a7)+,d4-d7/a3-a5    : restore registers
unlk          a6                  : remove locals
rts            : return

-----
ENDFUNC

macro
BwdStartH     &addrR,&A,&C

move.l        (&addrR)+,&A      ; 1H1G=(long *)addrR
move.l        &A,d0              ; A=1H1G, d0=1H1G
move.l        &A,&C              ; A=1H1G, d0=1H1G, C=1H1G
add.w         &A,d0              ; A=1H1G, d0=1H2G, C=1H1G
add.w         d0,&A              ; A=1H3G, d0=1H2G, C=1H1G
add.w         &A,d0              ; A=1H3G, d0=1H5G, C=1H1G
swap          &A                 ; A=3GH1, d0=1H5G, C=1H1G
sub.l         d0,&A              ; A=AAAA, d0=1H5G, C=1H1G

-----
endm

macro
BwdCycleH     &addrR,&addrW,&A,&B,&C

move.l        (&addrR)+,&B      ; 1H1G=(long *)addrR
move.l        &B,d0              ; B=1H1G, d0=1H1G
add.l         d0,d0              ; B=1H1G, d0=2H2G
move.l        d0,d1              ; B=1H1G, d0=2H2G, d1=2H2G
add.l         &B,d0              ; B=1H1G, d0=3H3G, d1=2H2G
add.l         d0,d1              ; B=1H1G, d0=3H3G, d1=5H5G
move.l        &B,d2              ; B=1H1G, d0=3H3G, d1=5H5G, d2=1H1G
move.w        d1,d2              ; B=1H1G, d0=3H3G, d1=5H5G, d2=1H5G
move.w        &B,d1              ; B=1H1G, d0=3H3G, d1=5H1G, d2=1H5G
move.w        d0,&B              ; B=1H3G, d0=3H3G, d1=5H1G, d2=1H5G
move.w        d1,d0              ; B=1H3G, d0=3H1G, d1=5H1G, d2=1H5G
swap          &B                 ; B=3G1H, d0=3H1G, d1=5H1G, d2=1H5G
swap          d0                 ; B=3G1H, d0=1G3H, d1=5H1G, d2=1H5G

```

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Engineering:KlmcCode:CompPict:Backward.a

```

sub.l    d2,&B      : B=3G1H-1H5G
add.l    d0,&A      : A+=1H3G
add.l    d1,&A      : A+=5G1H

asr.w    #2,&A      : A0>>=2
move.w   &A,&C      : C complete
asr.l    #2,&A      : A1>>=2
move.l   &C,(&addrW)+ : *(long *)addrW=DD
move.l   &A,&C      : C=A1XX

endm
-----
macro
BwdEndH    &addrR,&addrW,&A,&B,&C

move.l    (&addrR)+,d0 : 1H1G=*(long *)addrR
move.w    d0,d2        : d2=1G
lsl.w     #2,d2        : d2=4G
neg.w     d2           : d2=-4G
swap      d0           : d0=1G1H
add.w     d0,d2        : d2+=1H
move.l    d0,d1        : d0=1G1H, d1=1G1H
add.w     d0,d1        : d0=1G1H, d1=1G2H
add.w     d1,d0        : d0=1G3H, d1=1G2H
add.w     d0,d1        : d0=1G3H, d1=1G3H
swap      d1           : d0=1G3H, d1=5H1G
add.l     d0,&A        : A+=1G3H
add.l     d1,&A        : A+=5H1G

asr.w     #2,&A        : A1>>=2
move.w    &A,&C        : C complete
asr.l     #2,&A        : A0>>=2
move.l    &C,(&addrW)+ : *(long *)addrW=C
move.w    d2,&A        : A=D1D2
move.l    &A,(&addrW)+ : *(long *)addrW=A

endm
-----
macro
BwdH      &base,&end,&inc

movea.l   &base,a0      : addrR=base
movea.l   a0,a1         : addrW=addrR
BwdStartH a0,d3,d5      : BwdStart(addrR,A,DD)
;do BwdCycleH a0,a1,d3,d4,d5 : BwdCycle(addrR,addrW,A,B,C)
BwdCycleH a0,a1,d4,d3,d5 : BwdCycle(addrR,addrW,B,A,C)
cmpa.l    a0,&end       : addr2<end
bgt.s     0do           : while
BwdEndH   a0,a1,d3,d4,d5 : BwdEnd(addrR,addrW,A,B,DD)

endm
-----
BackJ511H  FUNC  EXPORT
PS         RECORD  8
data       DS.L   1
incl       DS.L   1
endl       DS.L   1
inc2       DS.L   1
end2       DS.L   1
ENDR

link       &A,00      : no local variables

```

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Engineering:KlicsCode:CompPict:Backward.a

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```

movem.l    d4-d7/a3-a5, -(a7)      ; store registers
.
move.l     PS,inc1(a6),d3           ; inc=inc1
movea.l    PS,data(a6),a5           ; base=data
edo        movea.l    a5,a4           ; end=base
adda.l     PS,end1(a6),a4           ; end+=end1
BwdH       a5,a4,d3                 ; Bwd(base,end,inc)
adda.l     PS,inc2(a6),a5           ; base+=inc2
cmpa.l     PS,end2(a6),a5           ; end2>base
blc.w      edo                      ; for
.
movem.l    (a7)+,d4-d7/a3-a5        ; restore registers
unlk       a6                       ; remove locals
rts        ; return
.
ENDFUNC
-----
END

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

.....
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
...../
/*
*   Full still/video Knowles-Lewis Image KlicsEncode System utilising KVS property
*   and delta-tree coding
*
*   Recoded and re-rationalised (Stand alone version)
*/

#include <PixMath.h>
#include <Bits3.h>
#include <Klics.h>
#include <KlicsHeader.h>
#include <KlicsEncode.h>

#include <Math.h>

/* If bool true the negate value */
#define negif(bool,value) ((bool)?-(value):(value))
#define abs(value) negif(value<0,value)

extern void HaarForward();
extern void Daub4Forward();

/* Use the bit level file macros (Bits2.h)
buf_use:*/

/* Huffman encode a block */
#define HuffEncLev(lev,buf) \
    HuffEncode(lev[0],buf); \
    HuffEncode(lev[1],buf); \
    HuffEncode(lev[2],buf); \
    HuffEncode(lev[3],buf);

/* Fixed length encode block of integers */
#define IntEncLev(lev,lpf_bits,buf) \
    IntEncode(lev[0],lpf_bits,buf); \
    IntEncode(lev[1],lpf_bits,buf); \
    IntEncode(lev[2],lpf_bits,buf); \
    IntEncode(lev[3],lpf_bits,buf);

/* Define write a zero */
#define Token0 \
    buf_winc(buf);

/* Define write a one */
#define Token1 \
    buf_set(buf); buf_winc(buf);

/* Write block for data and update memory */
#define DoXfer(addr,pro,lev,dst,mode,oct,rmode,buf) \
    HuffEncLev(lev,buf); \
    PutData(addr,pro,dst); \
    mode[oct]=oct==0?M_STOP:rmode;

/* Function Name: Quantize

```



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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

* Description:    H.261 style quantizer
* Arguments:    new, old - image blocks
*               pro, lev - returned values
*               q - quantizing divisor
* Returns:      lev is all zero, quantized data (pro) & level (lev)

```

```

void Quantize(int new[4], int old[4], int pro[4], int lev[4], short q)
{
    int blk, half_q=(1<<q)-1>>1;

    for(blk=0;blk<4;blk++) {
        int data=new[blk]-old[blk],
            mag_level=abs(data)>>q;

        mag_level=mag_level>135?135:mag_level;
        lev[blk]=negif(data<0,mag_level);
        pro[blk]=old[blk]-negif(data<0,(mag_level<<q)+(mag_level==0?half_q:0));
    }
    return(pro[0]==0 && pro[1]==0 && pro[2]==0 && pro[3]==0);
}

```

```

void QuantizeLPF(int new[4],int pro[4],int lev[4],short q)
{
    int blk, half_q=(1<<q)-1>>1;

    for(blk=0;blk<4;blk++) {
        int data=new[blk],
            mag_level=abs(data)>>q;

        lev[blk]=negif(data<0,mag_level);
        pro[blk]=(lev[blk]<<q)+half_q;
    }
}

```

```

/* Function Name:  GuessQuantize
* Description:    Estimate threshold quantiser value
* Arguments:    new, old - image blocks
*               q - q weighting factor
* Returns:      estimated q_const
*/

```

```

float GuessQuantize(int new[4],int old[4],float q)
{
    int blk;
    float qt_max=0.0;

    for(blk=0;blk<4;blk++) {
        int i, data=abs(new[blk]-old[blk]);
        float qt;

        for(i=0;data!=0;i++) data>>=1;
        if (i>0) i--;
        qt=((1<<i)-1)>>1/q;

        qt_max=qt_max>qt?qt_max:qt;
    }
    return(qt_max);
}

```

```

/* Function Name:  IntEncode
* Description:    Write a integer to bit file
* Arguments:    lev - integer to write now signed

```

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Engineering:KlipsCode:CompPict:KlipsEnc.c

```

    bits = no of bits
*/

void IntEncode(int lev, int bits, Buf buf)
{
    /* Old version
    int i;

    for(i=bits-1; i>=0; i--) {
        if ((lev&1)<<i) buf_set(buf);
        buf_winc(buf);
    }
    */
    /* New version
    int i, mag=abs(lev);
    Boolean sign=lev<0;

    if (1<<bits-1 <= mag) mag=(1<<bits-1)-1;
    if (sign) buf_set(buf);
    buf_winc(buf);
    for(i=1<<bits-2; i!=0; i>>=1) {
        if (mag&i) buf_set(buf);
        buf_winc(buf);
    }
    */
    /* Hardware compatible version: sign mag(lsb->msb) */
    int i, mag=abs(lev);
    Boolean sign=lev<0;

    if (1<<bits-1 <= mag) mag=(1<<bits-1)-1;
    if (sign) buf_set(buf);
    buf_winc(buf);
    for(i=1; i!=1<<bits-1; i<<=1) {
        if (mag&i) buf_set(buf);
        buf_winc(buf);
    }
}

/* Function Name: HuffEncodeSA
* Description: Write a Huffman coded integer to bit file
* Arguments: lev - integer value
* Returns: no of bits used
*/

void HuffEncode(int lev, Buf buf)
{
    /* int level=abs(lev);

    if (level>1) huf_set(buf);
    buf_winc(buf);
    if (level>2 || level==1) buf_set(buf);
    buf_winc(buf);
    if (level!=0) {
        if (lev<0) buf_set(buf);
        buf_winc(buf);
        if (level>2) {
            int i;

            for(i=3; i<level; i++) {
                buf_winc(buf);
            }
            buf_set(buf);
            buf_winc(buf);
        }
    }
    */
}

```

➤ Engineering:KlicsCode:CompPict:KlicsEnc.c

```

1*/
/* New version */
int level=abs(lev). i:

if (level!=0) buf_set(buf);
buf_winc(buf);
if (level!=0) {
    if (lev<0) buf_set(buf);
    buf_winc(buf);
    if (level<8) {
        while (l<level--)
            buf_winc(buf);
        buf_set(buf);
        buf_winc(buf);
    } else {
        for(i=0;i<7;i++)
            buf_winc(buf);
        level-=8;
        for(i=1<=6;i!=0;i>=1) {
            if (level&i) buf_set(buf);
            buf_winc(buf);
        }
    }
}

}

/* Function Name: KlicsEChannel
* Description: Encode a channel of image
* Arguments: src - source channel memory
*            dst - destination memory (and old for videos)
*            octs, size - octaves of decomposition and image dimensions
*            normals - MVS weighted normals
*            lpf_bits - no of bits for LPF integer (image coding only)
*/

void KlicsEncY(short *src,short *dst,int octs,int size[2],int thresh[5], int co
{
    int oct, mask, x, y, sub, tmp, step=2<<octs, blk[4], mode[4], nz, no, base;
    int addr[4], new[4], old[4], pro[4], lev[4], zero[e]=(0,0,0,0);
    Boolean nzflag, noflag, origin;
    int bitmask=1<<(kle->seqh.precision-kle->frmh.quantizer[0]-1);
    Buf buf=&kle->buf;

    for(y=0;y<size[1];y+=step)
    for(x=0;x<size[0];x+=step)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
                case M_VOID:
                    GetData(addr,old,dst);
                    if (BlkZero(old)) mode[oct]=M_STOP;
                    else { DoZero(addr,dst,mode,oct); }
                    break;
                case M_SEND|M_STILL:
                    GetData(addr,new,src);
                    nz=Decide(new); nzflag=nz<=thresh[octs-oct];
                    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer[octs-oct]))
                        GetData(addr,old,dst);
            }
        }
    }
}

```

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```

    Engineering:KlicsCode:CompPict:KlicsEnc.c

    if (BlkZero(old)) {
        Token0;
        mode[oct]=M_STOP;
    } else {
        Token1: Token1;
        DoZero(addr,dst,mode,oct);
    }
    } else {
        Token1: Token0;
        DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
    }
    break;
case M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    nz=Decide(new); nzflag=nz<=sthresh(octs-oct);
    if (BlkZero(old)) {
        if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer(octs-o
            Token0;
            mode[oct]=M_STOP;
        } else {
            Token1: Token0;
            DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
        }
    } else {
        int      oz=Decide(old), no=DecideDelta(new,old);
        Boolean motion=(nz+oz)>>oct <= no; /* motion detection */

        no=DecideDelta(new,old); noflag=no<=compare(octs-oct);
        origin=nz<=no;
        if ((!noflag || motion) && !nzflag) { /* was !noflag && !nzfl
            if (Quantize(new,origin?zero:old,pro,lev,kle->frmh.quantizer(o
                Token1: Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                if (origin) {
                    Token1: Token0;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
                } else {
                    Token1: Token1; Token1;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SEND,buf);
                }
            }
        } else {
            if ((!motion || origin) && nzflag) { /* was origin && nzfla
                Token1: Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                Token0;
                mode[oct]=M_STOP;
            }
        }
    }
    break;
case M_STILL:
    GetData(addr,new,src);
    nz=Decide(new); nzflag=nz<=sthresh(octs-oct);
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer(octs-oct))
        Token0;
        mode[oct]=M_STOP;
    } else {
        Token1:
        DoXfer(addr,pro,lev,dst,mode,oct,M_STILL,buf);
    }

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    }
    break;
case M_LPF|M_STILL:
    GetData(addr.new.src);
    QuantizeLPF(new.pro.lev.kle->frmh.quantizer(0));
    VerifyData(lev(0).bitmask,tmp);
    VerifyData(lev(1).bitmask,tmp);
    VerifyData(lev(2).bitmask,tmp);
    VerifyData(lev(3).bitmask,tmp);
    IntEncLev(lev.kle->seqh.precision-kle->frmh.quantizer(0).buf);
    PutData(addr.pro.dst);
    mode[oct]=M_QUIT;
    break;
case M_LPF|M_SEND:
    GetData(addr.new.src);
    GetData(addr.old.dst);
    nc=DecideDelta(new,old); noflag=no<=compare(octs-oct);
    if (noflag) {
        Token0;
    } else {
        Token1;
        Quantize(new,old.pro.lev.kle->frmh.quantizer(0));
        HuffEncLev(lev.buf);
        PutData(addr.pro.dst);
    }
    mode[oct]=M_QUIT;
    break;
}
switch(mode[oct]) {
case M_STOP:
    StopCounters(mode.oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode.oct,mask,blk);
    break;
}
} while (mode[oct]!=M_QUIT);
}

void KlicsEncUV(short *src,short *dst,int octs,int size[2],int thresh[5],int c
{
    int oct,mask,x,y,X,Y,sub,tmp,step=4<<octs,blk[4],mode[4],nz,no
    int addr[4],new[4],old[4],pro[4],lev[4],zero[4]={0,0,0,0};
    Boolean nzflag,noflag,origin;
    int bitmask=-1<<(kle->seqh.precision-kle->frmh.quantizer(0)-1);
    Buf buf=&kle->buf;

    for(Y=0;Y<size[1];Y+=step)
    for(X=0;X<size[0];X+=step)
    for(y=Y;y<size[1] && y<Y+step;y+=step>>1)
    for(x=X;x<size[0] && x<X+step;x+=step>>1)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] = M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
            case M_VOID:
                GetData(addr,old.dst);

```

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Engineering: KlicsCode: CompPict: KlicsEnd.c

```

if (BlkZero(old)) mode(oct)=M_STOP;
else { DoZero(addr,dst,mode,oct); }
break;
case M_SENDIM_STILL:
  GetData(addr,new,src);
  nz=Decide(new); nzflag=nz<=thresh(octs-oct);
  if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer(octs-oct))
    GetData(addr,old,dst);
    if (BlkZero(old)) {
      Token0;
      mode(oct)=M_STOP;
    } else {
      Token1; Token1;
      DoZero(addr,dst,mode,oct);
    }
  } else {
    Token1; Token0;
    DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
  }
  break;
case M_SEND:
  GetData(addr,new,src);
  GetData(addr,old,dst);
  nz=Decide(new); nzflag=nz<=thresh(octs-oct);
  if (BlkZero(old)) {
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer(octs-o
      Token0;
      mode(oct)=M_STOP;
    } else {
      Token1; Token0;
      DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
    }
  } else {
    int oz=Decide(old), no=DecideDelta(new,old);
    Bolean motion=(nz+oz)>>oct <= no; /* motion detection */
    no=DecideDelta(new,old); noflag=no<=compare(octs-oct);
    origin=nz<=no;
    if ((!noflag || motion) && !nzflag) { /* was !noflag && !nzfl
    if (Quantize(new,origin?zero:old,pro,lev,kle->frmh.quantizer(o
      Token1; Token1; Token0;
      DoZero(addr,dst,mode,oct);
    } else {
      if (origin) {
        Token1; Token0;
        DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
      } else {
        Token1; Token1; Token1;
        DoXfer(addr,pro,lev,dst,mode,oct,M_SEND,buf);
      }
    }
  } else {
    if ((motion || origin) && nzflag) { /* was origin && nzfla
      Token1; Token1; Token0;
      DoZero(addr,dst,mode,oct);
    } else {
      Token0;
      mode(oct)=M_STOP;
    }
  }
  break;
case M_STILL:

```

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Engineering:KlacsCode:CompPict:KlacsEnc.c

```

GetData(addr,new,src);
nz=Decide(new); nzflag=nz<=chresh[octs-oct];
if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer[octs-oct]);
    Token0;
    mode{oct}=M_STOP;
} else {
    Token1;
    DoXfer(addr,pro,lev,dst,mode{oct},M_STILL,buf);
}
break;
case M_LPFIM_STILL:
GetData(addr,new,src);
QuantizeLPF(new,pro,lev,kle->frmh.quantizer[0]);
VerifyData(lev[0],bitmask,tmp);
VerifyData(lev[1],bitmask,tmp);
VerifyData(lev[2],bitmask,tmp);
VerifyData(lev[3],bitmask,tmp);
IntEncLev(lev,kle->seqh.precision-kle->frmh.quantizer[0],buf);
PutData(addr,pro,dst);
mode{oct}=M_QUIT;
break;
case M_LPFIM_SEND:
GetData(addr,new,src);
GetData(addr,old,dst);
no=DecideDelta(new,old); noflag=no<=compare[octs-oct];
if (noflag) {
    Token0;
} else {
    Token1;
    Quantize(new,old,pro,lev,kle->frmh.quantizer[0]);
    HuffEncLev(lev,buf);
    PutData(addr,pro,dst);
}
mode{oct}=M_QUIT;
break;
}
switch(mode{oct}) {
case M_STOP:
    StopCounters(mode{oct},mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode{oct},mask,blk);
    break;
}
} while (mode{oct}!=M_QUIT);
}

/* index to quant and vice versa */
#define i2q(i) ((float)i*HISTO_DELTA/(float)HISTO
#define q2i(q) Fix2Long(X2Fix(q*(float)HISTO/HISTO_DELTA))

/* Function Name: LookAhead
* Description: Examine base of tree to calculate new quantizer value
* Arguments: src - source channel memory
*            dst - destination memory (and old for videos)
*            octs, size - octaves of decomposition and image dimensions
*            norms - base HVS weighted normals
* Returns: calculates new quant
*/

```

- 800 -

= Engineering:KlacsCode:CompPict:KlacsEnc.c

```

void LookAhead(short *src, short *dst, float norms[5][5], KlacsE kle)
{
    int x, y, sub, index, size[2] = {kle->seqh.sequence_size[0], kle->seqh.sequence_size[1]}, quact[HISTO], target;
    int new[4], old[4], addr[4], zero[4] = {0, 0, 0, 0};
    float quant;

    for(index=0; index<HISTO; index++) {
        thresh[index]=0;
        quact[index]=0;
    }
    for(y=0; y<size[1]; y+=2<<octs)
    for(x=0; x<size[0]; x+=2<<octs)
    for(sub=1; sub<4; sub++) {
        float q_thresh;
        int nz, no, oz, blk;
        Boolean ozflag, origin, motion;

        GetAddr(addr, x, y, sub, octs-1, size, 1<<octs);
        GetData(addr, new, src);
        GetData(addr, old, dst);
        nz=Decide(new);
        oz=Decide(old);
        no=DecideDelta(new, old);
        ozflag=kle->encl.intra || BlkZero(old);
        origin=nz<no;
        motion=(nz+oz)>>octs <= no;
        q_thresh=(float)nz/DecideDouble(norms[1][1]);
        if (ozflag || origin) {
            float qt=GuessQuantize(new, zero, norms[1][0]);
            q_thresh=q_thresh<qt?q_thresh:qt;
        } else {
            float qt=GuessQuantize(new, old, norms[1][0]);
            q_thresh=q_thresh<qt?q_thresh:qt;
            if (!motion) {
                qt=(float)no/DecideDouble(norms[1][2]);
                q_thresh=q_thresh<qt?q_thresh:qt;
            }
        }
        index=q2i(q_thresh);
        index=index<0?0:index>HISTO-1?HISTO-1:index;
        thresh[index]++;
    }
    for(index=HISTO-1; index>=0; index--)
        quact[index]=thresh[index]*index+(index==HISTO-1?0:quact[index+1]);

    /* buffer must be greater than bfp_in after this frame */
    /* buffer must be less than buff_size-bfp_in */
    target=kle->encl.bfp_out*kle->encl.prevquact/kle->encl.prevbytes; /* previous
    index=1;
    while(index<HISTO && quact[index]/index>target) index++;
    quant=i2q(index);

    kle->encl.tmp_quant=(kle->encl.tmp_quant+quant)/2.0;
    kle->encl.tmp_quant=i2q((index=q2i(kle->encl.tmp_quant))); /* forward and reve
    kle->encl.prevquact=quact[index]/(index==0?1:index);
}
/* Function Name: BaseNormals

```



- 801 -

Engineering:KlicsCode:CompPint:KlicsEnc.c

- Description: Calculates base HVS weighted normals
- Arguments: norms - storage for normals
- Returns: weighted normals

/\*

void BaseNormals(float norms[5][3],KlicsE kle)

{

```
float base_norm[3]=(1.0,kle->encl.thresh,kle->encl.compare);
int norm,oct;
```

```
for(oct=0;oct<5;oct++)
```

```
for(norm=0;norm<3;norm++)
```

```
norms[oct][norm]=base_norm[norm]*kle->encl.base[oct]*(float)1<<kl
```

}

/\* Function Name: Normals

- Description: Calculates HVS weighted normals @ quant
- Arguments: norms - storage for normals
- Returns: weighted normals and LPF bits

/\*

void Normals(float base\_norms[5][3],int thresh[5],int compare[5],KlicsE kle)

{

```
int oct, i, norm;
```

```
for(oct=0;oct<=kle->seqh.octaves[0];oct++) {
```

```
norm=Fix2Long(X2Fix(base_norms[oct][0]*kle->encl.tmp_quant));
```

```
norm=norm<171?norm:
```

```
for(i=0;i!=(norm&3);i++)
```

```
norm=norm>>1;
```

```
switch(norm) {
```

```
case 1:
```

```
kle->frmh.quantizer[oct]=i;
```

```
break;
```

```
case 2:
```

```
kle->frmh.quantizer[oct]=i+1;
```

```
break;
```

```
case 3:
```

```
case 4:
```

```
kle->frmh.quantizer[oct]=i+2;
```

}

```
thresh[oct]=Fix2Long(X2Fix(DecideDouble(base_norms[oct][1]*kle->encl.tmp_q
```

```
compare[oct]=Fix2Long(X2Fix(DecideDouble(base_norms[oct][2]*kle->encl.tmp_
```

```
kle->frmh.quantizer[0]=kle->frmh.quantizer[0]<3?3:kle->frmh.quantizer[0];
```

```
/* minimum 4 bits of quant for lpf due to dynamic range problems */
```

}

Boolean KlicsFlags(KlicsE kle)

{

```
Boolean skip=false;
```

```
kle->encl.buffer=kle->encl.bpf_in;
```

```
kle->frmh.flags=0;
```

```
if (kle->encl.buffer<0)
```

```
kle->encl.buffer=0;
```

```
if (kle->encl.intra)
```

```
kle->frmh.flags |= KFH_INTRA;
```

```
else
```

```
if (skip=kle->encl.buf_sw && kle->encl.buffer>=kle->encl.buf_size)
```

```
kle->frmh.flags |= KFH_SKIP;
```

```
return(skip);
```

- 802 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

.. Function Name: KlicsEncode
.. Description:   Encode a frame from YUV (de)transformed image
.. Arguments:    src - source image(s)
..               dst - transformed destination memory (and old for videos)
..

```

```

long KlicsEncode(short *src[3], short *dst[3], KlicsE kle)
{
    float base_norms[5][3];
    int    channel, thresh[5], compare[5];
    Buf    buf=&kle->buf;

    buf_winit(buf);
    if (KlicsFlags(kle))
        kle->frmh.length=0;
    else {
        for(channel=0; channel<kle->seqh.channels; channel++) {
            int size[2]=(kle->seqh.sequence_size[0]>>(channel==0?0:kle->seqh.s
                kle->seqh.sequence_size[1]>>(channel==0?0:kle->seqh.sub_sa
                area=size[0]*size[1], octs=kle->seqh.octaves[channel==0?0:

            switch(kle->seqh.wavelet) {
            case WT_Haar:
                HaarForward(src[channel], size, octs);
                break;
            case WT_Daub4:
                Daub4Forward(src[channel], size, octs);
                break;
            }

            BaseNormals(base_norms, kle);
            if (kle->encd.auto_q && !kle->encd.intra)
                LookAhead(src[0], dst[0], base_norms, kle);
            else
                kle->encd.tmp_quant=kle->encd.quant;
            Normals(base_norms, thresh, compare, kle);
            for(channel=0; channel<kle->seqh.channels; channel++) {
                int size[2]=(kle->seqh.sequence_size[0]>>(channel==0?0:kle->seqh.s
                    kle->seqh.sequence_size[1]>>(channel==0?0:kle->seqh.sub_sa
                    octs=kle->seqh.octaves[channel==0?0:1];

                if (kle->encd.intra)
                    KLZERO(dst[channel], size[0]*size[1]);
                if (channel==0) KlicsEncY(src[channel], dst[channel], octs, size, thresh, c
                else KlicsEncUV(src[channel], dst[channel], octs, size, thresh, compare, kle
            }
            buf_flush(buf);
            kle->frmh.length=buf_size(buf);
            kle->encd.buffer=&kle->frmh.length;
            if (!kle->encd.intra)
                kle->encd.prevbytes=kle->frmh.length;
        }
        return(kle->frmh.length);
    }
}

```

- 803 -

Engineering:KlicsCode:CompPict:KlicsHeader.h

```

.....
*
*  © Copyright 1993 KLICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*
...../
*
*  Sequence and frame headers for Klics-Encoded files
*  High byte first
*/

typedef struct {
    unsigned short  description_length; /* Fixed      - Size of this or parent struc
    unsigned char   version_number(2); /* Fixed      - Version and revision numbers
} KlicsHeader;

typedef struct {
    KlicsHeader head; /* Fixed      - Size and version of this str
    unsigned short sequence_size(3); /* Source    - Luminance dimensions and num
    unsigned char  channels; /* Source    - Number of channels: 3 - YUV,
    unsigned char  sub_sample(2); /* Source    - UV sub-sampling in X and Y d
    unsigned char  wavelet; /* Source    - Wavelet used: 0 - Haar, 1 -
    unsigned char  precision; /* Source    - Bit precision for transform
    unsigned char  octaves(2); /* Source    - Number of octaves Y/UV (maxi
    unsigned char  reserved(3); /* Fixed     - Reserved for future use */
} KlicsSeqHeader;

typedef struct {
    KlicsHeader head; /* Fixed      - Size and version of this str
    unsigned long  length; /* Calc      - Length of frame data (bytes)
    unsigned long  frame_number; /* Calc     - Frame number intended for se
    unsigned char  flags; /* Calc     - Bitfield flags: 0 - frame sk
    unsigned char  quantizer(5); /* Calc     - Quantiser shift values(octav
    unsigned short reserved; /* Fixed     - Reserved for future use */
} KlicsFrameHeader;

#define KFH_SKIP    0x1
#define KFH_INTRA   0x2

/*
*  Implementation notes :
*  QuickTime  Must have KlicsFrameHeader.length set to a valid number
*  Sun        Must have KlicsSeqHeader in data stream
*
*  Possible developments:
*  KlicsFrameHeader.quantizer
*  Currently contains shift rather than step-size
*  Different values for UV and CH, HG, CG sub-bands are not currently suppo
*/

```

- 804 -

Engineering:KlicsCode:Klics Codec:KlicsEncode.r

```

/*
 * KlicsEncode resource file
 */

#include "Types.r"
#include "MPWTypes.r"
#include "ImageCodec.r"

/*
 * Klics Compressor included into the applications resource file here
 */

#define klicsCodecFormatName    'Klics'
#define klicsCodecFormatType    'klic'

/*
 * This structure defines the capabilities of the codec. There will
 * probably be a tool for creating this resource, which measures the performance
 * and capabilities of your codec.
 */
resource 'cdc:' (129, 'Klics CodecInfo'.locked) {
    klicsCodecFormatName, /* name of the codec TYPE ( da
    1, /* version */
    1, /* revision */
    'klic', /* who made this codec */
    0,
    codecInfoDoes32|codecInfoDoes8|codecInfoDoesTemporal, /* depth and etc suppo
    codecInfoDepth24|codecInfoSequenceSensitive, /* which data formats do we up
    100, /* compress accuracy (0-255) (
    100, /* decompress accuracy (0-255)
    0, /* millisecs to compress 320x2
    0, /* millisecs to decompress 320
    0, /* compression level (0-255) (
    0,
    32, /* minimum height */
    32, /* minimum width */
    0,
    0,
    0
};

resource 'chrg' (128, 'Klics Compressor'.locked) {
    compressorComponentType,
    klicsCodecFormatType,
    'klic',
    codecInfoDoes32|codecInfoDoes8|codecInfoDoesTemporal,
    0,
    'cdc',
    128,
    'STR ',
    128,
    'STR ',
    129,
    'ICON',
    128
};

resource 'STR ' (128) {
    'Klics Compress'

```

- 805 -

➤ Engineering:KlicsCode:Klics Codec:KlicsEncoder

);

resource 'STR' (129) (

'Wavelet transform & multiresolution tree based coding scheme'

);

- 806 -

Engineering:KlicsCode:Klics Codec:KlicsDeccode.r

```

/*
 * KlicsDeccode resource file
 */

#include "Types.r"
#include "MPATypes.r"
#include "ImageCodec.r"

/*
 * Klics Compressor included into the applications resource file here
 */

#define klicsCodecFormatName    'Klics'
#define klicsCodecFormatType    'klic'

/*
 * This structure defines the capabilities of the codec. There will
 * probably be a tool for creating this resource, which measures the performance
 * and capabilities of your codec.
 */
resource 'cdci' (129, 'Klics CodecInfo'.locked) {
    klicsCodecFormatName,          /* name of the codec TYPE ( da
    1,                             /* version */
    1,                             /* revision */
    'klic',                       /* who made this codec */
    codecInfoDoes32|codecInfoDoes16|codecInfoDoes8|codecInfoDoesTemporal|codecInfo
    0,
    codecInfoDepth24|codecInfoSequenceSensitive, /* which data formats do we un-
    100,                             /* compress accuracy (0-255) (
    100,                             /* decompress accuracy (0-255)
    0,                             /* millisecs to compress 320x2
    0,                             /* millisecs to decompress 320
    0,                             /* compression level (0-255) (
    0,
    32,                             /* minimum height */
    32,                             /* minimum width */
    0,
    0,
    0
};

resource 'rhng' (130, 'Klics Decompressor'.locked) {
    decompressorComponentType,
    klicsCodecFormatType,
    'klic',
    codecInfoDoes32|codecInfoDoes16|codecInfoDoes8|codecInfoDoesTemporal|codecInfo
    0,
    'cdec',
    128,
    'STR ',
    130,
    'STR ',
    131,
    'ICON',
    130
};

resource 'STR ' (130) {

```

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CLAIMS

## WE CLAIM:

1. A method of transforming a sequence of input digital data values into a first sequence of transformed digital data values and of inverse transforming a second sequence of transformed digital data values into a sequence of output digital data values, said sequence of input digital data values comprising a boundary subsequence and a non-boundary subsequence, comprising the steps of:
  - 10 running a number of said input digital data values of said boundary subsequence through a low pass boundary forward transform perfect reconstruction digital filter and through a high pass boundary forward transform perfect reconstruction digital filter to produce a first subsequence of said first sequence of transformed digital data values, said first subsequence of said first sequence of transformed digital data values comprising interleaved low and high frequency transformed digital data values;
  - 20 running a number of said input digital data values of said non-boundary subsequence through a low pass non-boundary forward transform perfect reconstruction digital filter and also through a high pass non-boundary forward transform perfect reconstruction digital filter to produce a second subsequence of said first sequence of transformed digital data values, said second subsequence of said first sequence of transformed digital data values comprising interleaved low and high frequency transformed digital data values, said low pass boundary forward transform perfect reconstruction digital filter having a fewer number of coefficients than said low pass non-boundary forward transform perfect reconstruction digital filter, said high pass boundary forward transform perfect reconstruction digital filter having a fewer number of coefficients

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than said high pass non-boundary forward transform  
perfect reconstruction digital filter;

converting said first sequence of transformed  
digital data values into said second sequence of  
transformed digital data values, said second sequence  
of transformed digital data values comprising a first  
subsequence of said second sequence of transformed  
digital data values and a second subsequence of said  
second sequence of transformed digital data values;

running a number of said first subsequence of  
said second sequence of transformed digital data  
values through an interleaved boundary inverse  
transform perfect reconstruction digital filter to  
produce at least one output digital data value;

running a number of said second subsequence of  
said second sequence of transformed digital data  
values through a first interleaved non-boundary  
inverse transform perfect reconstruction digital  
filter to produce output digital data values; and

running a number of said second subsequence of  
transformed digital data values through a second  
interleaved non-boundary inverse transform perfect  
reconstruction digital filter to produce output  
digital data values, said output digital data values  
produced by said interleaved boundary inverse  
transform perfect reconstruction digital filter, said  
first interleaved non-boundary inverse transform  
perfect reconstruction digital filter, and said second  
interleaved non-boundary inverse transform perfect  
reconstruction digital filter comprising a subsequence  
of said output digital data values of said sequence of  
output digital data values.

2. The method of Claim 1, wherein said low pass  
boundary forward transform perfect reconstruction digital  
filter has X coefficients and wherein said low pass non-  
boundary forward transform perfect reconstruction digital



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filter has  $Y$  coefficients,  $Y$  being greater than  $X$ , said  $X$  coefficients of said low pass boundary forward transform perfect reconstruction digital filter being chosen so that said low pass boundary forward transform perfect reconstruction digital filter outputs a transformed digital data value  $H_0$  when the low pass boundary forward perfect transform reconstruction digital filter operates on input digital data values  $ID_0-ID_{X-1}$  adjacent said boundary, said transformed digital data value  $H_0$  being substantially equal to what the output of the low pass non-boundary forward transform perfect reconstruction digital filter would be were the low pass non-boundary forward perfect reconstruction digital filter to operate on  $ID_0-ID_{X-1}$  as well as  $Y-X$  additional input digital data values outside said boundary, said additional input digital data values having preselected values.

3. The method of Claim 2, wherein  $Y-X=1$ , wherein there is one additional input digital data value  $ID_{-1}$ , and wherein  $ID_{-1}$  is preselected to be substantially equal to  $ID_0$ .

4. The method of Claim 2, wherein  $Y-X=1$ , wherein there is one additional input digital data value  $ID_{-1}$ , and wherein  $ID_{-1}$  is preselected to be substantially equal to zero.

5. The method of Claim 1, wherein said sequence of input digital data values is a sequence of digital data values associated with pixels of either a row or a column of a two dimensional image, said boundary of said sequence of input digital data values corresponding with either a start or an end of said row or said column.

6. The method of Claim 1, wherein said sequence of input digital data values is a sequence of digital data values associated with an audio signal.

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7. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction digital filters are forward transform quasi-perfect reconstruction filters which have coefficients which approximate the coefficients of true forward transform perfect reconstruction filters.

8. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction digital filters are both four coefficient quasi-Daubechies filters the coefficients of which approximate the coefficients of true four coefficient Daubechies filters.

9. The method of Claim 8, wherein one of said four coefficient quasi-Daubechies filters has the coefficients  $11/32$ ,  $19/32$ ,  $5/32$  and  $3/32$  independent of sign.

10. The method of Claim 1, wherein said low pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter  $H$  of the form:

$$H_n = aID_{2n-1} + bID_{2n} + cID_{2n+1} - dID_{2n+2}$$

$n$  being a positive integer,  $ID_0-ID_m$  being input digital data values,  $m$  being a positive integer,  $ID_0$  being the first input digital data value in said sequence of input digital data values, and wherein said low pass boundary forward transform perfect reconstruction digital filter is a three coefficient digital filter of the form:

$$H_0 = aID_{-1} + bID_0 + cID_1 - dID_2$$

$ID_{-1}$  being a predetermined input digital data value outside said boundary and having a preselected value.

11. The method of Claim 10, wherein said high pass

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non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter of the form:

$$G_n = dID_{2n-1} + cID_{2n} - bID_{2n+1} + aID_{2n+2}$$

5 n being a positive integer, and wherein said high pass boundary forward transform perfect reconstruction digital filter is a three coefficient digital filter of the form:

$$G_0 = dID_{-1} + cID_0 - bID_1 + aID_2$$

dID<sub>-1</sub> having a preselected value.

10 12. The method of Claim 11, wherein:  $a + b + c - d$  is substantially equal to 1, wherein  $a - b + c + d$  is substantially equal to 0, and wherein  $ac - bd$  is substantially equal to zero.

13. The method of Claim 12, wherein:  $a=11/32$ ,  
15  $b=19/32$ ,  $c=5/32$  and  $d=3/32$ .

14. The method of Claim 11, wherein said interleaved boundary inverse transform perfect reconstruction digital filter is a two coefficient digital filter of the form:

$$OD_0 = 4(b-a)H_0 + 4(c-d)G_0$$

20 wherein  $OD_0$  is an output digital data value of said sequence of output digital data values, wherein  $G_0$  is the output of said high pass boundary forward transform perfect reconstruction digital filter when the high pass boundary forward transform perfect reconstruction digital  
25 filter operates on input digital data values  $ID_0$ ,  $ID_1$  and  $ID_2$  adjacent said boundary, and wherein  $H_0$  is the output of said low pass boundary forward transform perfect reconstruction digital filter when the low pass boundary

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forward transform perfect reconstruction digital filter operates on input digital data values  $ID_0$ ,  $ID_1$  and  $ID_2$  adjacent said boundary.

15        15. The method of Claim 14, wherein one of said first and second interleaved non-boundary inverse transform perfect reconstruction digital filters is of the form:

$$D_{2n+1} = 2(cH_n - bG_n + aH_{n+1} + dG_{n+1})$$

n being a non-negative integer, and wherein the other of said first and second interleaved non-boundary inverse  
10 perfect reconstruction digital filters is of the form:

$$D_{2n+2} = 2(-dH_n + aG_n + bH_{n+1} + cG_{n+1})$$

n being a non-negative integer, wherein  $H_n$ ,  $G_n$ ,  $H_{n+1}$  and  $G_{n+1}$  comprise a subsequence of said second sequence of transformed digital data values.

15        16. The method of Claim 1, wherein said low pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter having the coefficients:  $11/32$ ,  $19/32$ ,  $5/32$  and  $-3/32$ , and wherein said high pass non-boundary forward transform perfect  
20 reconstruction digital filter is a four coefficient quasi-Daubechies filter having the coefficients:  $3/32$ ,  $5/32$ ,  $-19/32$  and  $11/32$ .

17. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction  
25 digital filters are chosen from the group consisting of: true six coefficient Daubechies filters and quasi-Daubechies filters, the coefficients of the quasi-Daubechies filters approximating the coefficients of true six coefficient Daubechies filters.

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18. The method of Claim 1, further comprising the steps of:

encoding said first sequence of transformed digital data values into an encoded sequence; and  
5 decoding said encoded sequence of digital data values into said second sequence of transformed digital data values and supplying said second sequence of transformed digital data values to said interleaved boundary inverse transform perfect reconstruction  
10 digital filter, said first interleaved non-boundary inverse transform perfect reconstruction digital filter, and said second interleaved non-boundary inverse transform perfect reconstruction digital filter.

15 19. The method of Claim 18, further comprising the step of:

quantizing each of said digital data values in said first sequence of transformed values before said encoding step.

20 20. The method of Claim 1, wherein each of said input digital data values of said sequence of input digital data values is stored in a separate memory location, and wherein some of said memory locations are overwritten in a sequence with said sequence of transformed digital data values as  
25 said digital data input values are transformed into said transformed digital data values.

21. A method of transforming a sequence of input digital data values into a sequence of transformed digital data values, said sequence of input digital data values  
30 comprising a boundary subsequence and a non-boundary subsequence, comprising the steps of:

running a number of said input digital data values of said boundary subsequence through a low pass boundary forward transform perfect reconstruction

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digital filter and through a high pass boundary  
forward transform perfect reconstruction digital  
filter to produce a first subsequence of said sequence  
of transformed digital data values, said first  
5 subsequence of said sequence of transformed digital  
data values comprising interleaved low and high  
frequency transformed digital data values; and  
running a number of said input digital data  
values of said non-boundary subsequence through a low  
10 pass non-boundary forward transform perfect  
reconstruction digital filter and also through a high  
pass non-boundary forward transform perfect  
reconstruction digital filter to produce a second  
subsequence of said sequence of transformed digital  
15 data values, said second subsequence of said sequence  
of transformed digital data values comprising  
interleaved low and high frequency transformed digital  
data values, said low pass boundary forward transform  
perfect reconstruction digital filter having a fewer  
20 number of coefficients than said low pass non-boundary  
forward transform perfect reconstruction digital  
filter, said high pass boundary forward transform  
perfect reconstruction digital filter having a fewer  
number of coefficients than said high pass non-  
25 boundary forward transform perfect reconstruction  
digital filter.

22. A method, comprising the steps of:

generating a sub-band decomposition having a  
plurality of octaves, a first of said plurality of  
30 octaves comprising at least one first digital data  
value, a second of said plurality of octaves  
comprising at least one second digital data value;  
calculating a sum of the absolute values of said  
at least one first digital data value;  
35 determining if said at least one first digital  
data value is interesting using a first threshold

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limit;

calculating a sum of the absolute values of said  
at least one second digital data value; and

5 determining if said at least one second digital  
data value is interesting using a second threshold  
limit.

23. A method of traversing a tree decomposition, said  
tree decomposition comprising a plurality of transformed  
data values, each of said plurality of transformed data  
10 values having a unique address identified by coordinates X  
and Y, comprising the step of:

calculating at least four transformed data value  
addresses by incrementing a count, the count  
comprising one bit  $C1_x$  in the X coordinate and one bit  
15  $C1_y$  in the Y coordinate, to generate said at least  
four transformed data value addresses.

24. A method, comprising the step of:

determining an address of a transformed data value in  
a tree decomposition by shifting a value a number of times,  
20 said tree decomposition having a number of octaves, said  
transformed data value being in one of said octaves, said  
number of times being at least dependent upon said one  
octave.

25. A method, comprising the step of:

25 determining an address of a transformed data value in  
a tree decomposition by multiplying a value by a factor,  
said tree decomposition having a number of octaves, said  
transformed data value being in one of said octaves, said  
factor being at least dependent upon said one octave.

30 26. A method, comprising the step of:

determining an address of a transformed data value in  
a tree decomposition by shifting a value a number of times,  
said tree decomposition having a number of frequency sub-

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bands, said transformed data value being in one of said frequency sub-bands, said number of times being at least dependent upon said frequency sub-band.

27. A method, comprising the step of:

5 determining an address of a transformed data value in a tree decomposition by performing a logical operation upon a value, said tree decomposition having a number of frequency sub-bands, said transformed data value being in one of said frequency sub-bands, said logical operation  
10 performed being at least dependent upon said one frequency sub-band.

28. The method of Claim 27, wherein said logical operation is a bit-wise logical AND operation.

29. A method for determining a low pass quasi-perfect  
15 reconstruction filter and a high pass quasi-perfect reconstruction filter from a wavelet function, said low pass quasi-perfect reconstruction filter having a plurality of coefficients, said high pass quasi-perfect reconstruction filter having a plurality of coefficients,  
20 comprising the steps of:

determining a low pass wavelet digital filter and a high pass wavelet digital filter from said wavelet function, said low pass wavelet digital filter having a plurality of coefficients, said high pass wavelet digital  
25 filter having a plurality of coefficients;

choosing the coefficients of said low pass quasi-perfect reconstruction digital filter to be fractions such that when a sequence of data values having values of 1 is processed by said low pass quasi-perfect reconstruction  
30 digital filter the output of said low pass quasi-perfect reconstruction digital filter is exactly a power of 2; and

choosing the coefficients of the high pass quasi-perfect reconstruction digital filter to be fractions such that when a sequence of data values having values of 1 is



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processed by said high pass quasi-perfect reconstruction digital filter the output of said high pass quasi-perfect reconstruction digital filter is exactly 0, whereby each of the plurality of coefficients of said low pass quasi-perfect reconstruction digital filter is substantially identical to a corresponding one of said plurality of coefficients of said low pass wavelet digital filter, and whereby each of the plurality of coefficients of said high pass quasi-perfect reconstruction digital filter is substantially identical to a corresponding one of said plurality of coefficients of said high pass wavelet digital filter.

30. A method of estimating a compression ratio of a number of original data values to a number of compressed data values at a value of a quality factor Q, comprising the steps of:

examining a first block of transformed data values of a tree, said first block being one of a number of lowest frequency blocks of a high pass component sub-band, said tree being part of a sub-band decomposition; and

determining a value of said quality factor Q at which said data values of said first block would be converted into compressed data values, and not determining a value of said quality factor Q at which any other block of data values of said tree would be converted into a number of compressed data values.

31. The method of Claim 30, wherein said number of original data values represents a frame of an image.

32. The method of Claim 31, further comprising the step of:

determining a number of lowest frequency blocks of said high pass component sub-band which would be converted into compressed data values given a value of said quality factor Q.

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33. A method of transforming a sequence of image data values, comprising the step of:

filtering said sequence of image data values using a quasi-perfect reconstruction filter to generate a decomposition having a plurality of octaves, said quasi-perfect reconstruction filter having six coefficients.

34. The method of Claim 33, wherein said six coefficients are selected from the group consisting of: 30/128, 73/128, 41/128, 12/128, 7/128 and 3/128, irrespective of sign.

35. A method of detecting motion in a tree decomposition, said tree decomposition comprising a plurality of octaves of blocks of data values, comprising the steps of:

15 comparing data values of a first block in an octave with data values of a second block in said octave; and generating a token indicating motion based on said comparing.

36. A method, comprising the steps of:

20 generating a sub-band decomposition having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a second of said plurality of octaves comprising at least one second digital data value;

25 determining if said at least one first digital data value is interesting using a first threshold limit; and determining if said at least one second digital data value is interesting using a second threshold limit.

37. A method, comprising the steps of:

30 generating a sub-band decomposition of a first frame having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a

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second of said plurality of octaves comprising at least one second digital data value;

generating a sub-band decomposition of a second frame having a plurality of octaves, a first of said plurality of 5 octaves comprising at least one first digital data value, a second of said plurality of octaves comprising at least one second digital data value;

comparing said first digital data value of said first frame with said first digital data value of said second 10 frame using a first threshold compare; and

comparing said second digital data value of said first frame with said second digital data value of said second frame using a second threshold compare.

38. A method, comprising the steps of:

15 reading a sequence of data values from a plurality of memory locations, each of said data values being stored in a separate one of said plurality of memory locations; and  
overwriting some of said memory locations in a sequence as said data values are transformed into a  
20 sequence of transformed data values of a sub-band decomposition.

39. A method, comprising the steps of:

performing a function on a plurality of data values of a new block to generate a first output value, said new 25 block being a block of data values of a sub-band decomposition of a new frame;

performing said function on a plurality of numbers to generate a second output value, each of said numbers substantially equalling a difference of a data value in  
30 said plurality of data values of said new block and a corresponding data value in a corresponding plurality of data values of an old block, said old block being a block of data values of a sub-band decomposition of an old frame;  
and

35 generating a token if said first output value has a

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predetermined relationship with respect to said second output value.

40. The method of Claim 39, wherein said token is a SEND\_STILL token.

5        41. A method, comprising the steps of:  
performing a function on a plurality of data values of a new block to generate a corresponding plurality of output values, said new block being a block of data values of a sub-band decomposition;  
10        comparing each of said plurality of output values with a predetermined number; and  
generating a token if substantially all of said output values have a predetermined relationship with respect to said predetermined number.

15        42. The method of Claim 41, wherein said token is a VOID token.

43. A method, comprising the steps of:  
subtracting each one of a plurality of data values of a new block with a corresponding one of a plurality of data  
20 values of a old block to generate a corresponding plurality of output values, said new block being a block of data values of a sub-band decomposition of a new frame, said old block being a block of data values of a sub-band decomposition of a old frame;  
25        comparing each of said plurality of output values with a predetermined number; and  
generating a token if substantially all of said output values have a predetermined relationship with respect to said predetermined number.

30        44. The method of Claim 43, wherein said token is a VOID token.

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45. A method, comprising the steps of:  
determining an absolute value for each of a plurality  
of data values of a block of a sub-band decomposition;  
determining a sum of said absolute values; and  
5 generating a token based on a comparison of said sum  
with a predetermined number.

46. The method of Claim 45, wherein said token is a  
VOID token.

47. A method, comprising the steps of:  
10 processing a sequence of first image data values using  
a low pass forward transform perfect reconstruction digital  
filter and a high pass forward transform perfect  
reconstruction digital filter to create a first sequence of  
transformed data values, said low pass forward transform  
15 perfect reconstruction digital filter and said high pass  
forward transform perfect reconstruction digital filter  
each having coefficients chosen from a first group of  
coefficients independent of sign;  
converting said first sequence of transformed data  
20 values into a second sequence of transformed data values;  
and  
using digital circuitry to process said second  
sequence of transformed data values using a low pass  
inverse transform perfect reconstruction digital filter and  
25 a high pass inverse transform perfect reconstruction  
digital filter into a sequence of second image data values,  
said low pass inverse transform perfect reconstruction  
digital filter and said high pass inverse transform perfect  
reconstruction digital filter each having coefficients  
30 chosen from a second group of coefficients independent of  
sign.

48. The method of claim 47, wherein said digital  
circuitry used to process said second sequence of  
transformed data values is a digital computer having a

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microprocessor.

49. The method of claim 47, wherein at least one of the coefficients in said first group of coefficients is not contained in said second group of coefficients.

5 50. The method of claim 47, wherein said first group of coefficients has a different number of coefficients than said second group of coefficients.

51. The method of claim 50, wherein said sequence of first image data values is a sequence of chrominance data  
10 values.

52. The method of claim 50, wherein said low pass forward transform perfect reconstruction digital filter and said high pass forward transform perfect reconstruction digital filter each have four coefficients, and wherein  
15 said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter each have two coefficients.

53. The method of claim 52, wherein said sequence of first image data values is a sequence of chrominance data  
20 values.

54. The method of claim 47, wherein each of said coefficients of said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter is selected  
25 from the group consisting of:  $5/8$ ,  $3/8$  and  $1/8$ , independent of sign.

55. The method of claim 47, wherein said converting step comprises the steps of:

encoding said first sequence of transformed data  
30 values into a compressed data stream; and

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decoding said compressed data stream into said second sequence of transformed data values.

56. A method comprising the step of using digital circuitry to process a sequence of image data values using  
5 a low pass forward transform perfect reconstruction digital filter and a high pass forward transform perfect reconstruction digital filter to generate a sub-band decomposition, said low pass forward transform perfect reconstruction digital filter and said high pass forward  
10 transform perfect reconstruction digital filter each having four coefficients, each of said four coefficients being selected from the group consisting of:  $5/8$ ,  $3/8$  and  $1/8$ , independent of sign.

57. The method of claim 56, wherein said digital  
15 circuitry comprises means for low pass forward transform perfect reconstruction digital filtering and for high pass forward transform perfect reconstruction digital filtering.

58. A method comprising the step of using digital circuitry to process a sequence of transformed data values  
20 of a sub-band decomposition using an odd inverse transform perfect reconstruction digital filter and an even inverse transform perfect reconstruction digital filter, said odd inverse transform perfect reconstruction digital filter and said even inverse transform perfect reconstruction digital  
25 filter each having four coefficients, each of said four coefficients being selected from the group consisting of:  $5/8$ ,  $3/8$  and  $1/8$ , independent of sign.

59. The method of claim 58, wherein said digital circuitry is a digital computer having a microprocessor.

30 60. A method comprising the step of generating a compressed data stream indicative of a video sequence from a sub-band decomposition, said compressed data stream

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comprising a first data value, a first token, a second data value, and a second token, said first token being indicative of a first encoding method used to encode said first data value, said second token being indicative of a second encoding method used to encode said second data value, said first token consisting of a first number of bits and said second token consisting of a second number of bits.

61. The method of claim 60, wherein said first encoding method is taken from the group consisting of: SEND mode, STILL\_SEND mode, VOID mode, and STOP mode.

62. The method of claim 60, wherein said first token is a single bit token.

63. A method, comprising the steps of:

15 forward transforming image data values to generate a first sequence of transformed data values of a first sub-band decomposition, said first sub-band decomposing having a first number of octaves;

converting said first sequence of transformed data values into a second sequence of transformed data values;

20 using digital circuitry to inverse transforming said second sequence of transformed data values into a third sequence of transformed data values, said third sequence of transformed data values comprising a second sub-band decomposition having a second number of octaves, said second number of octaves being smaller than said first number of octaves, said second sub-band decomposition having a low pass component, said low pass component of said second sub-band decomposition comprising data values

25 indicative of rows of data values of an image, said rows of said image extending in a first dimension, said image also having columns of said data values extending in a second dimension;

expanding said low pass component in said first

30



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dimension using interpolation to generate an interpolated low pass component; and

expanding said interpolated low pass component in said second dimension by replicating rows of said data values of 5 said interpolated low pass component.

64. The method of claim 63, wherein said digital circuitry is a digital computer having a microprocessor.

65. The method of claim 63, wherein said converting step comprises the steps of:

10 encoding said first sequence of transformed data values into a compressed data stream comprising tokens and encoded data values; and

decoding said compressed data stream into said second sequence of transformed data values.

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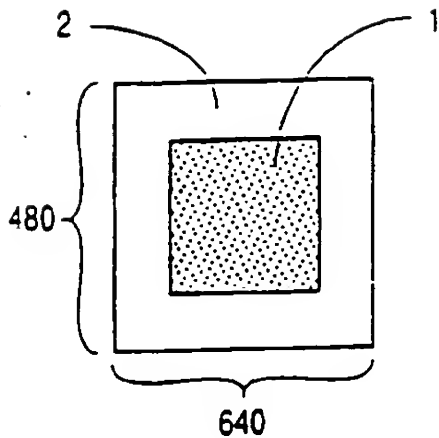


Fig. 1  
(PRIOR ART)

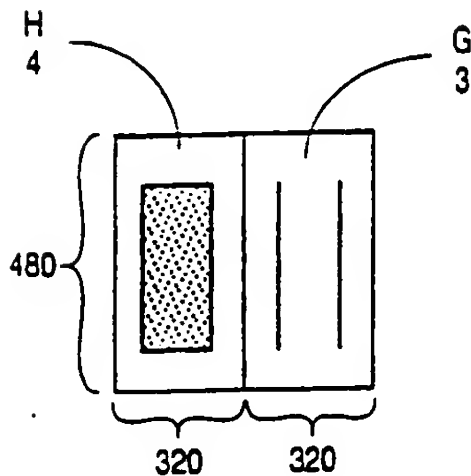


Fig. 2  
(PRIOR ART)

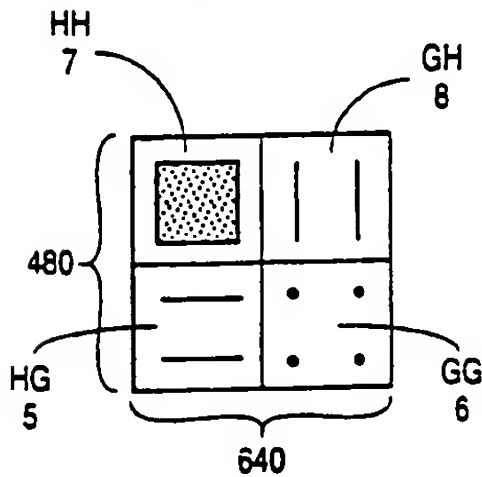


Fig. 3  
(PRIOR ART)

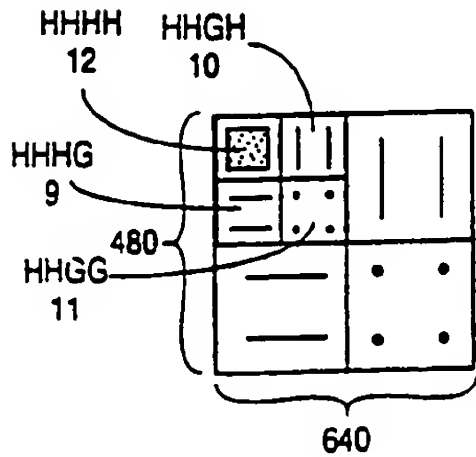


Fig. 4  
(PRIOR ART)

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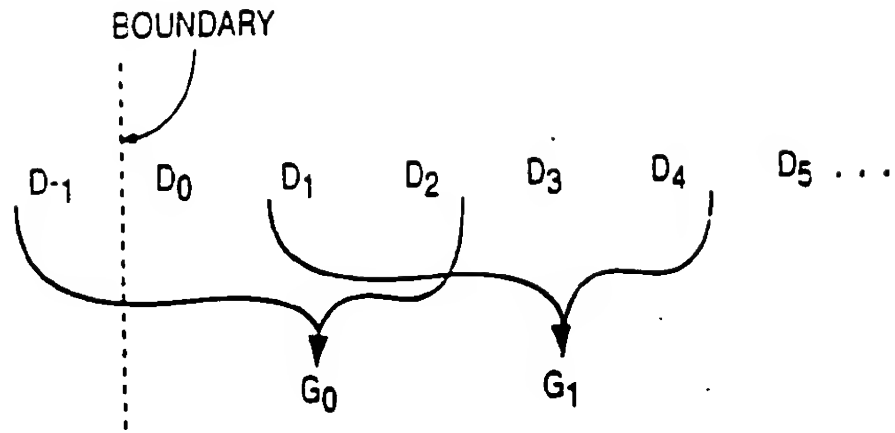


Fig. 5  
(PRIOR ART)

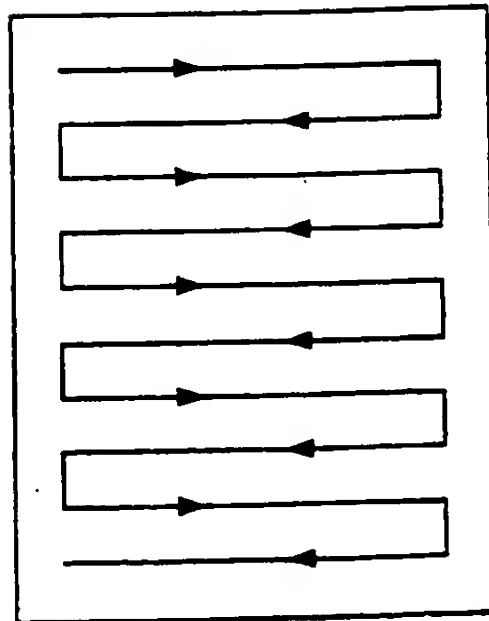


Fig. 6  
(PRIOR ART)

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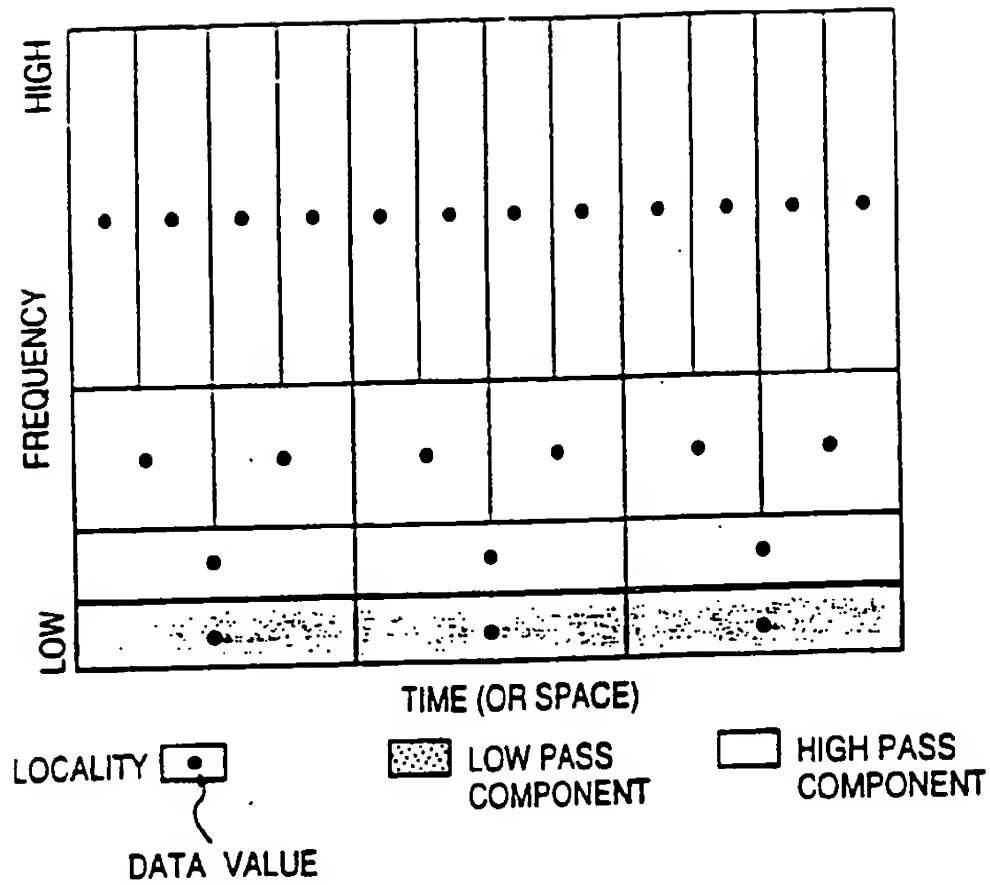


Fig. 7

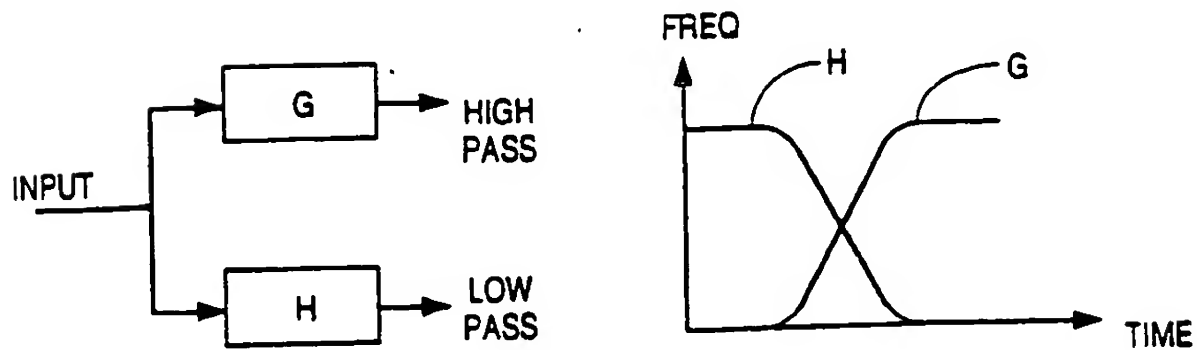


Fig. 8

Fig. 9

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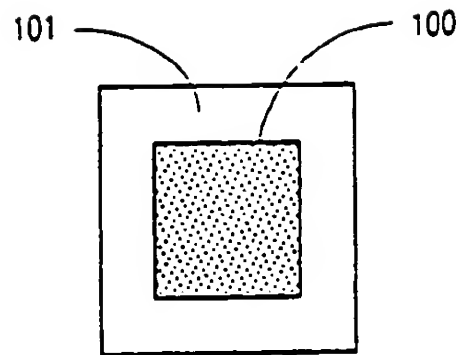


Fig. 10

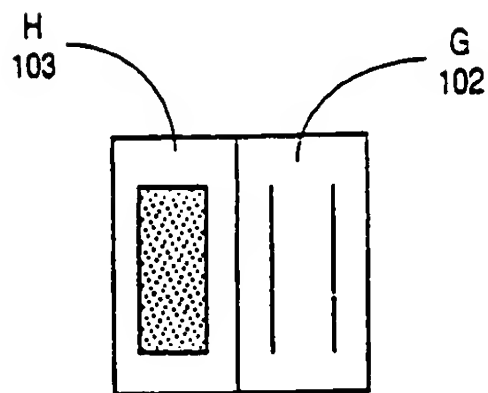


Fig. 11

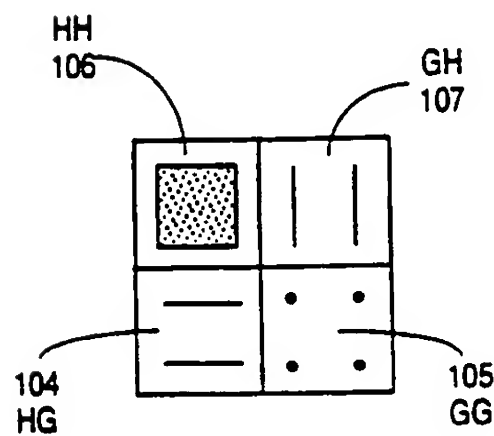


Fig. 14

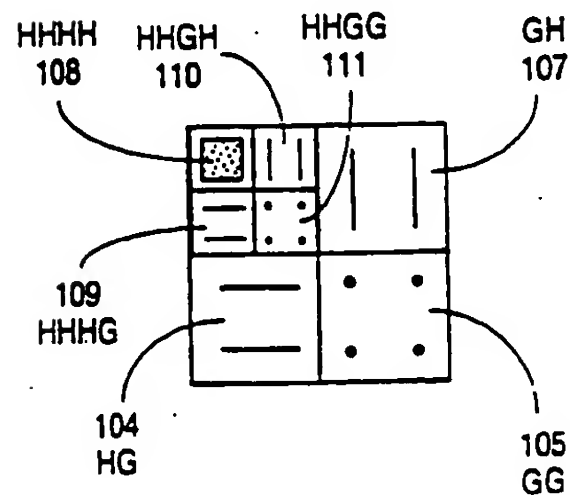


Fig. 15

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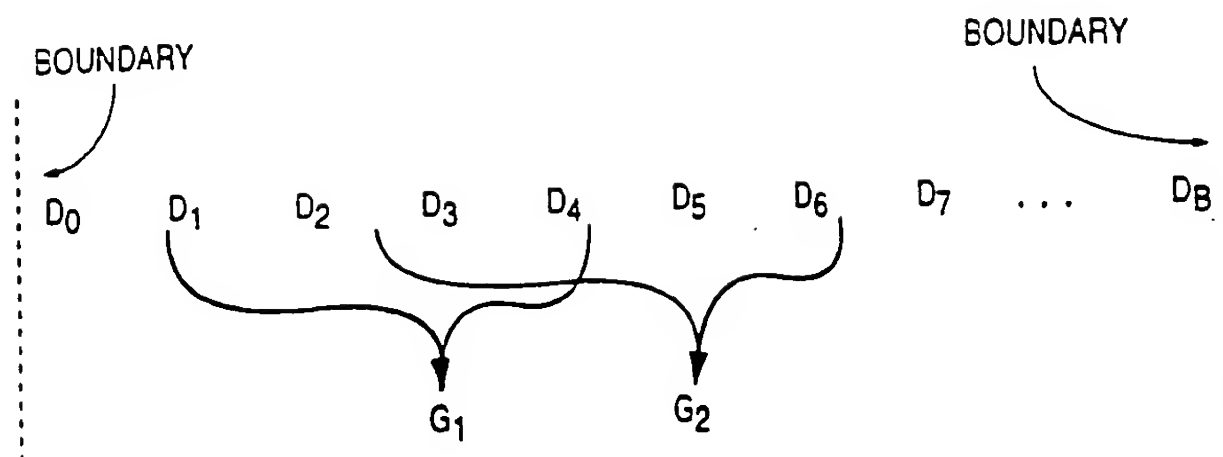


Fig. 12

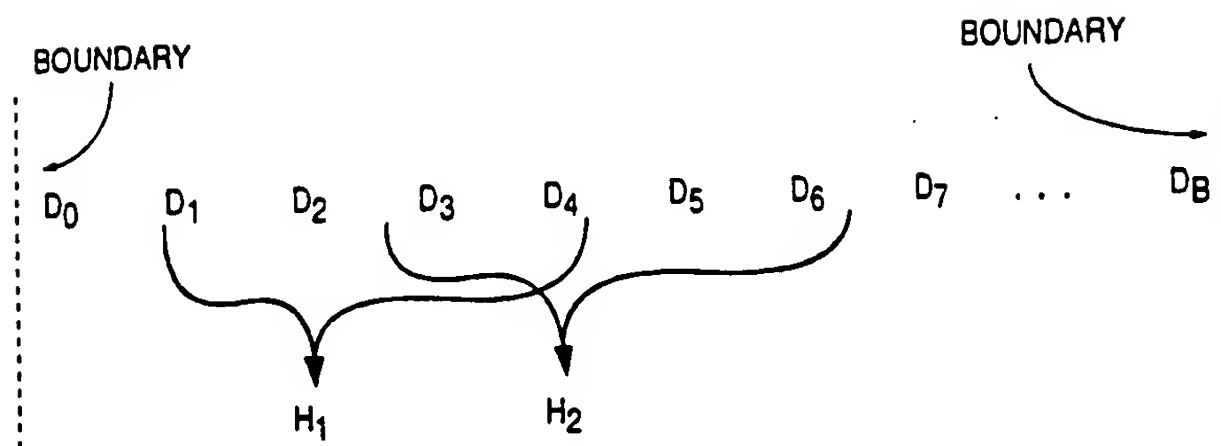


Fig. 13

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| COLUMN |     |     |     |     |     |     |     |     |     |     |     |     |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|        | 0   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | A   | B   |
| 0      | D00 | D01 | D02 | D03 | D04 | D05 | D06 | D07 | D08 | D09 | D0A | D0B |
| 1      | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D1A | D1B |
| 2      | D20 | D21 | D22 | D23 | D24 | D25 | D26 | D27 | D28 | D29 | D2A | D2B |
| 3      | D30 | D31 | D32 | D33 | D34 | D35 | D36 | D37 | D38 | D39 | D3A | D3B |
| 4      | D40 | D41 | D42 | D43 | D44 | D45 | D46 | D47 | D48 | D49 | D4A | D4B |
| 5      | D50 | D51 | D52 | D53 | D54 | D55 | D56 | D57 | D58 | D59 | D5A | D5B |
| 6      | D60 | D61 | D63 | D63 | D64 | D65 | D66 | D67 | D68 | D69 | D6A | D6B |
| 7      | D70 | D71 | D72 | D73 | D74 | D75 | D76 | D77 | D78 | D79 | D7A | D7B |
| 8      | D80 | D81 | D82 | D83 | D84 | D85 | D86 | D87 | D88 | D89 | D8A | D8B |
| 9      | D90 | D91 | D92 | D93 | D94 | D95 | D96 | D97 | D98 | D99 | D9A | D9B |
| A      | DA0 | DA1 | DA2 | DA3 | DA4 | DA5 | DA6 | DA7 | DA8 | DA9 | DAA | DAB |
| B      | DB0 | DB1 | DB2 | DB3 | DB4 | DB5 | DB6 | DB7 | DB8 | DB9 | DBA | DBB |

R  
O  
W

Fig. 16

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|   | COLUMN |      |      |      |      |      |      |      |      |      |      |
|---|--------|------|------|------|------|------|------|------|------|------|------|
|   | 0      | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | B    |
| 0 | HH00   | GH00 | HH01 | GH01 | HH02 | GH02 | HH03 | GH03 | HH04 | GH04 | HH05 |
| 1 | HG00   | GG00 | HG01 | GG01 | HG02 | GG02 | HG03 | GG03 | HG04 | GG04 | HG05 |
| 2 | HH10   | GH10 | HH11 | GH11 | HH12 | GH12 | HH13 | GH13 | HH14 | GH14 | HH15 |
| 3 | HG10   | GG10 | HG11 | GG11 | HG12 | GG12 | HG13 | GG13 | HG14 | GG14 | HG15 |
| 4 | HH20   | GH20 | HH21 | GH21 | HH22 | GH22 | HH23 | GH23 | HH24 | GH24 | HH25 |
| 5 | HG20   | GG20 | HG21 | GG21 | HG22 | GG22 | HG23 | GG23 | HG24 | GG24 | HG25 |
| 6 | HH30   | GH30 | HH31 | GH31 | HH32 | GH32 | HH33 | GH33 | HH34 | GH34 | HH35 |
| 7 | HG30   | GG30 | HG31 | GG31 | HG32 | GG32 | HG33 | GG33 | HG34 | GG34 | HG35 |
| 8 | HH40   | GH40 | HH41 | GH41 | HH42 | GH42 | HH43 | GH43 | HH44 | GH44 | HH45 |
| 9 | HG40   | GG40 | HG41 | GG41 | HG42 | GG42 | HG43 | GG43 | HG44 | GG44 | HG45 |
| A | HH50   | GH50 | HH51 | GH51 | HH52 | GH52 | HH53 | GH53 | HH54 | GH54 | HH55 |
| B | HG50   | GG50 | HG51 | GG51 | HG52 | GG52 | HG53 | GG53 | HG54 | GG54 | HG55 |

Fig. 17



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| COLUMN |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |
|--------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|        | 0                                   | 1                                   | 2                                   | 3                                   | 4                                   | 5                                   | 6                                   | 7                                   | 8                                   | 9                                   | A                                   | B                                   |
| 0      | HHHH <sub>00</sub> GH <sub>00</sub> | HHGH <sub>00</sub> GH <sub>01</sub> | HHHH <sub>01</sub> GH <sub>02</sub> | HHGH <sub>01</sub> GH <sub>03</sub> | HHHH <sub>02</sub> GH <sub>04</sub> | HHGH <sub>02</sub> GH <sub>05</sub> | HHHH <sub>03</sub> GH <sub>06</sub> | HHGH <sub>03</sub> GH <sub>07</sub> | HHHH <sub>04</sub> GH <sub>08</sub> | HHGH <sub>04</sub> GH <sub>09</sub> | HHHH <sub>05</sub> GH <sub>10</sub> | HHGH <sub>05</sub> GH <sub>11</sub> |
| 1      | HG <sub>00</sub> GG <sub>00</sub>   | HG <sub>01</sub> GG <sub>01</sub>   | HG <sub>02</sub> GG <sub>02</sub>   | HG <sub>03</sub> GG <sub>03</sub>   | HG <sub>04</sub> GG <sub>04</sub>   | HG <sub>05</sub> GG <sub>05</sub>   | HG <sub>06</sub> GG <sub>06</sub>   | HG <sub>07</sub> GG <sub>07</sub>   | HG <sub>08</sub> GG <sub>08</sub>   | HG <sub>09</sub> GG <sub>09</sub>   | HG <sub>10</sub> GG <sub>10</sub>   | HG <sub>11</sub> GG <sub>11</sub>   |
| 2      | HHHG <sub>00</sub> GH <sub>10</sub> | HHGG <sub>00</sub> GH <sub>11</sub> | HHHG <sub>01</sub> GH <sub>12</sub> | HHGG <sub>01</sub> GH <sub>13</sub> | HHHG <sub>02</sub> GH <sub>14</sub> | HHGG <sub>02</sub> GH <sub>15</sub> | HHHG <sub>03</sub> GH <sub>16</sub> | HHGG <sub>03</sub> GH <sub>17</sub> | HHHG <sub>04</sub> GH <sub>18</sub> | HHGG <sub>04</sub> GH <sub>19</sub> | HHHG <sub>05</sub> GH <sub>20</sub> | HHGG <sub>05</sub> GH <sub>21</sub> |
| 3      | HG <sub>10</sub> GG <sub>10</sub>   | HG <sub>11</sub> GG <sub>11</sub>   | HG <sub>12</sub> GG <sub>12</sub>   | HG <sub>13</sub> GG <sub>13</sub>   | HG <sub>14</sub> GG <sub>14</sub>   | HG <sub>15</sub> GG <sub>15</sub>   | HG <sub>16</sub> GG <sub>16</sub>   | HG <sub>17</sub> GG <sub>17</sub>   | HG <sub>18</sub> GG <sub>18</sub>   | HG <sub>19</sub> GG <sub>19</sub>   | HG <sub>20</sub> GG <sub>20</sub>   | HG <sub>21</sub> GG <sub>21</sub>   |
| 4      | HHHH <sub>10</sub> GH <sub>20</sub> | HHGH <sub>10</sub> GH <sub>21</sub> | HHHH <sub>11</sub> GH <sub>22</sub> | HHGH <sub>11</sub> GH <sub>23</sub> | HHHH <sub>12</sub> GH <sub>24</sub> | HHGH <sub>12</sub> GH <sub>25</sub> | HHHH <sub>13</sub> GH <sub>26</sub> | HHGH <sub>13</sub> GH <sub>27</sub> | HHHH <sub>14</sub> GH <sub>28</sub> | HHGH <sub>14</sub> GH <sub>29</sub> | HHHH <sub>15</sub> GH <sub>30</sub> | HHGH <sub>15</sub> GH <sub>31</sub> |
| 5      | HG <sub>20</sub> GG <sub>20</sub>   | HG <sub>21</sub> GG <sub>21</sub>   | HG <sub>22</sub> GG <sub>22</sub>   | HG <sub>23</sub> GG <sub>23</sub>   | HG <sub>24</sub> GG <sub>24</sub>   | HG <sub>25</sub> GG <sub>25</sub>   | HG <sub>26</sub> GG <sub>26</sub>   | HG <sub>27</sub> GG <sub>27</sub>   | HG <sub>28</sub> GG <sub>28</sub>   | HG <sub>29</sub> GG <sub>29</sub>   | HG <sub>30</sub> GG <sub>30</sub>   | HG <sub>31</sub> GG <sub>31</sub>   |
| 6      | HHHG <sub>10</sub> GH <sub>30</sub> | HHGG <sub>10</sub> GH <sub>31</sub> | HHHG <sub>11</sub> GH <sub>32</sub> | HHGG <sub>11</sub> GH <sub>33</sub> | HHHG <sub>12</sub> GH <sub>34</sub> | HHGG <sub>12</sub> GH <sub>35</sub> | HHHG <sub>13</sub> GH <sub>36</sub> | HHGG <sub>13</sub> GH <sub>37</sub> | HHHG <sub>14</sub> GH <sub>38</sub> | HHGG <sub>14</sub> GH <sub>39</sub> | HHHG <sub>15</sub> GH <sub>40</sub> | HHGG <sub>15</sub> GH <sub>41</sub> |
| 7      | HG <sub>30</sub> GG <sub>30</sub>   | HG <sub>31</sub> GG <sub>31</sub>   | HG <sub>32</sub> GG <sub>32</sub>   | HG <sub>33</sub> GG <sub>33</sub>   | HG <sub>34</sub> GG <sub>34</sub>   | HG <sub>35</sub> GG <sub>35</sub>   | HG <sub>36</sub> GG <sub>36</sub>   | HG <sub>37</sub> GG <sub>37</sub>   | HG <sub>38</sub> GG <sub>38</sub>   | HG <sub>39</sub> GG <sub>39</sub>   | HG <sub>40</sub> GG <sub>40</sub>   | HG <sub>41</sub> GG <sub>41</sub>   |
| 8      | HHHH <sub>20</sub> GH <sub>40</sub> | HHGH <sub>20</sub> GH <sub>41</sub> | HHHH <sub>21</sub> GH <sub>42</sub> | HHGH <sub>21</sub> GH <sub>43</sub> | HHHH <sub>22</sub> GH <sub>44</sub> | HHGH <sub>22</sub> GH <sub>45</sub> | HHHH <sub>23</sub> GH <sub>46</sub> | HHGH <sub>23</sub> GH <sub>47</sub> | HHHH <sub>24</sub> GH <sub>48</sub> | HHGH <sub>24</sub> GH <sub>49</sub> | HHHH <sub>25</sub> GH <sub>50</sub> | HHGH <sub>25</sub> GH <sub>51</sub> |
| 9      | HG <sub>40</sub> GG <sub>40</sub>   | HG <sub>41</sub> GG <sub>41</sub>   | HG <sub>42</sub> GG <sub>42</sub>   | HG <sub>43</sub> GG <sub>43</sub>   | HG <sub>44</sub> GG <sub>44</sub>   | HG <sub>45</sub> GG <sub>45</sub>   | HG <sub>46</sub> GG <sub>46</sub>   | HG <sub>47</sub> GG <sub>47</sub>   | HG <sub>48</sub> GG <sub>48</sub>   | HG <sub>49</sub> GG <sub>49</sub>   | HG <sub>50</sub> GG <sub>50</sub>   | HG <sub>51</sub> GG <sub>51</sub>   |
| A      | HHHG <sub>20</sub> GH <sub>50</sub> | HHGG <sub>20</sub> GH <sub>51</sub> | HHHG <sub>21</sub> GH <sub>52</sub> | HHGG <sub>21</sub> GH <sub>53</sub> | HHHG <sub>22</sub> GH <sub>54</sub> | HHGG <sub>22</sub> GH <sub>55</sub> | HHHG <sub>23</sub> GH <sub>56</sub> | HHGG <sub>23</sub> GH <sub>57</sub> | HHHG <sub>24</sub> GH <sub>58</sub> | HHGG <sub>24</sub> GH <sub>59</sub> | HHHG <sub>25</sub> GH <sub>60</sub> | HHGG <sub>25</sub> GH <sub>61</sub> |
| B      | HG <sub>50</sub> GG <sub>50</sub>   | HG <sub>51</sub> GG <sub>51</sub>   | HG <sub>52</sub> GG <sub>52</sub>   | HG <sub>53</sub> GG <sub>53</sub>   | HG <sub>54</sub> GG <sub>54</sub>   | HG <sub>55</sub> GG <sub>55</sub>   | HG <sub>56</sub> GG <sub>56</sub>   | HG <sub>57</sub> GG <sub>57</sub>   | HG <sub>58</sub> GG <sub>58</sub>   | HG <sub>59</sub> GG <sub>59</sub>   | HG <sub>60</sub> GG <sub>60</sub>   | HG <sub>61</sub> GG <sub>61</sub>   |

Fig. 18

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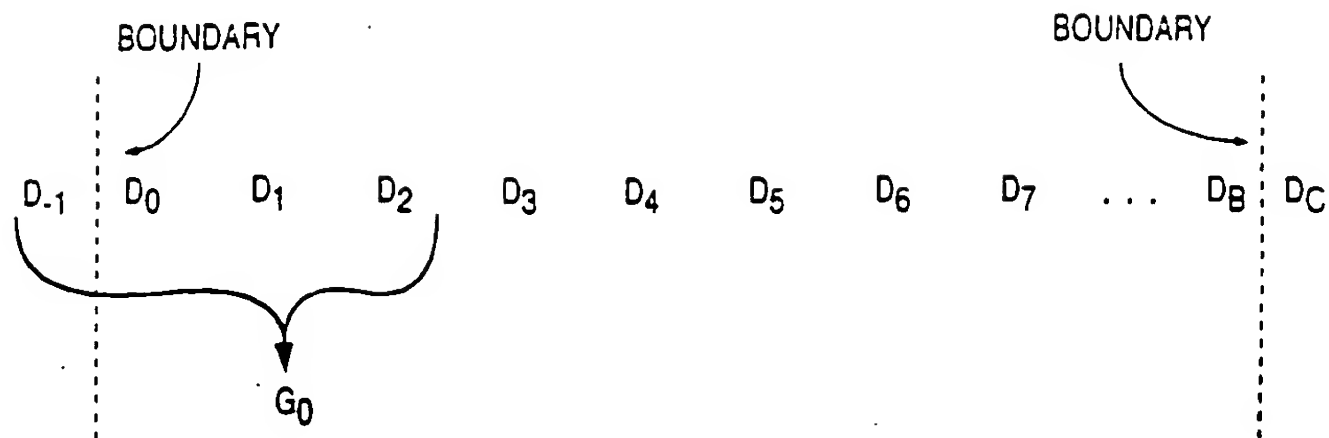


Fig. 19

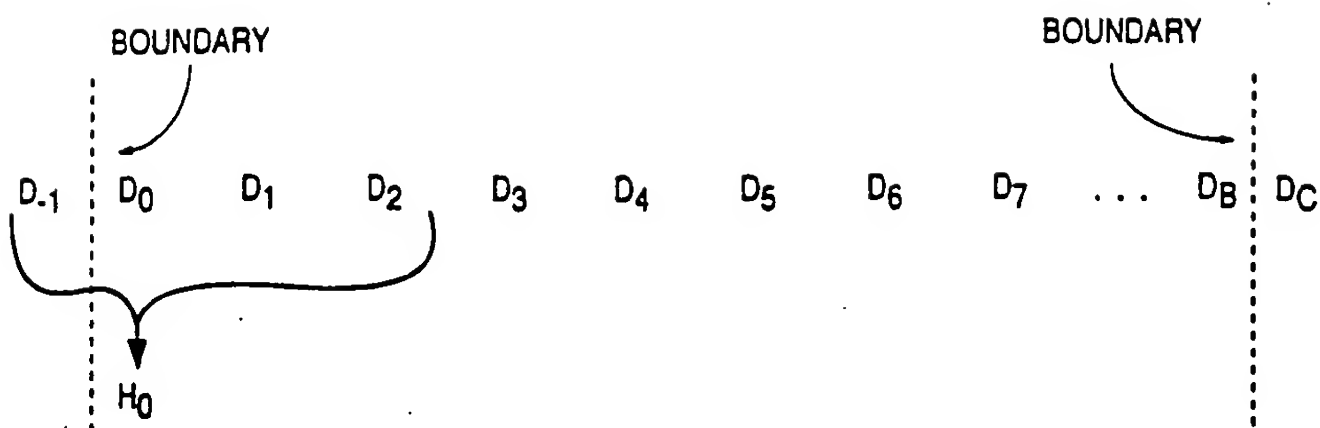


Fig. 20

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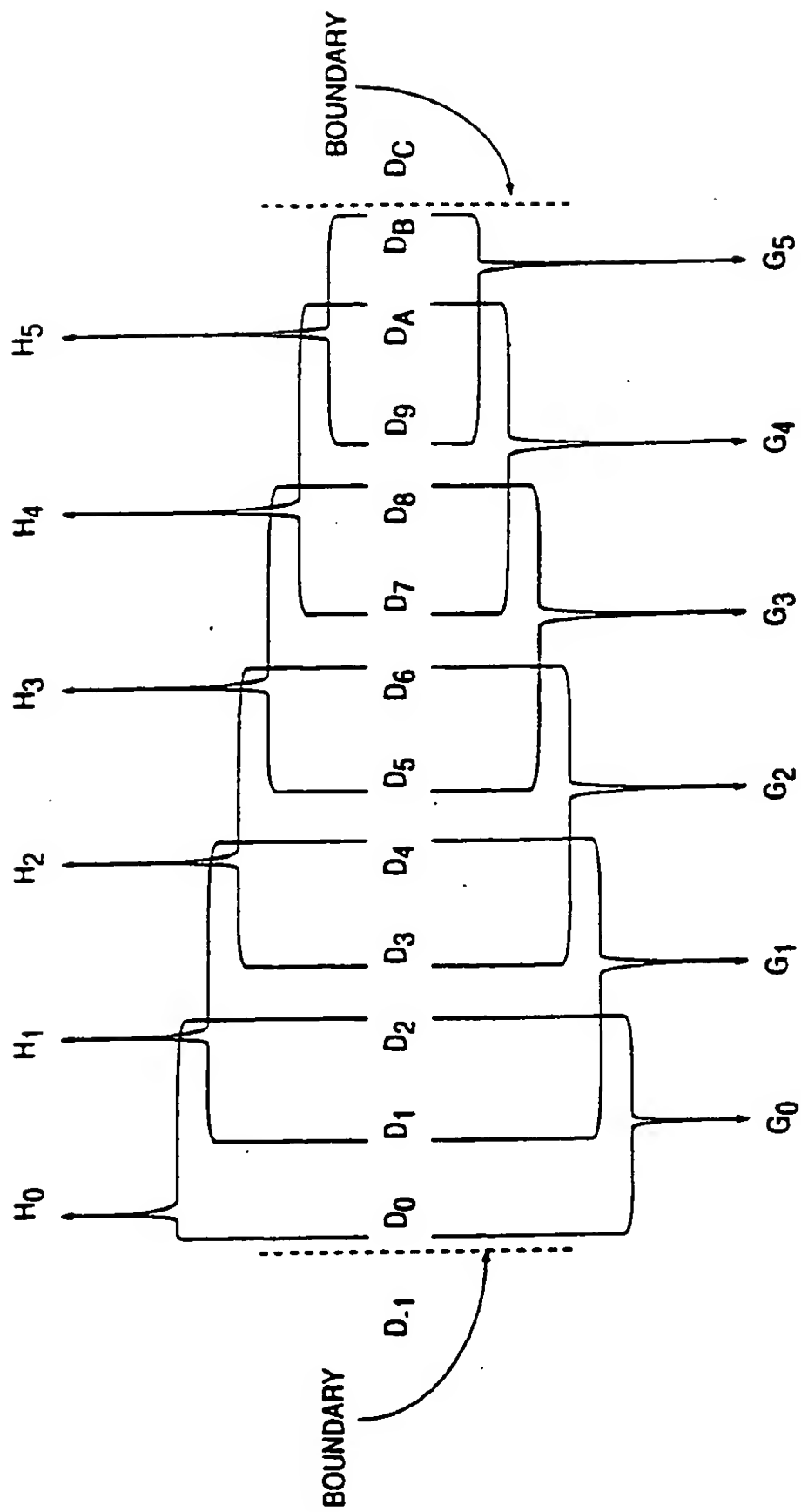


Fig. 21

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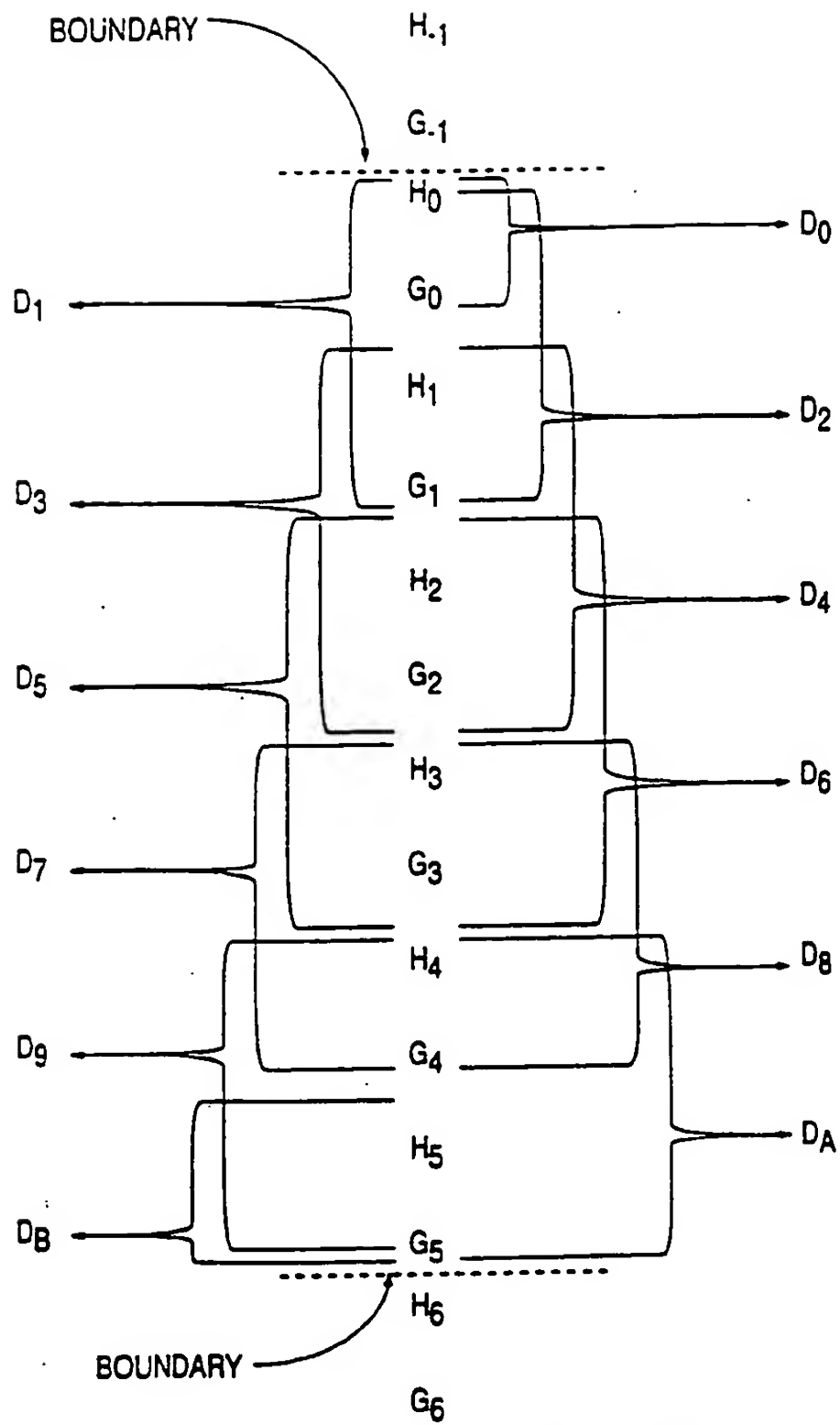


Fig. 22

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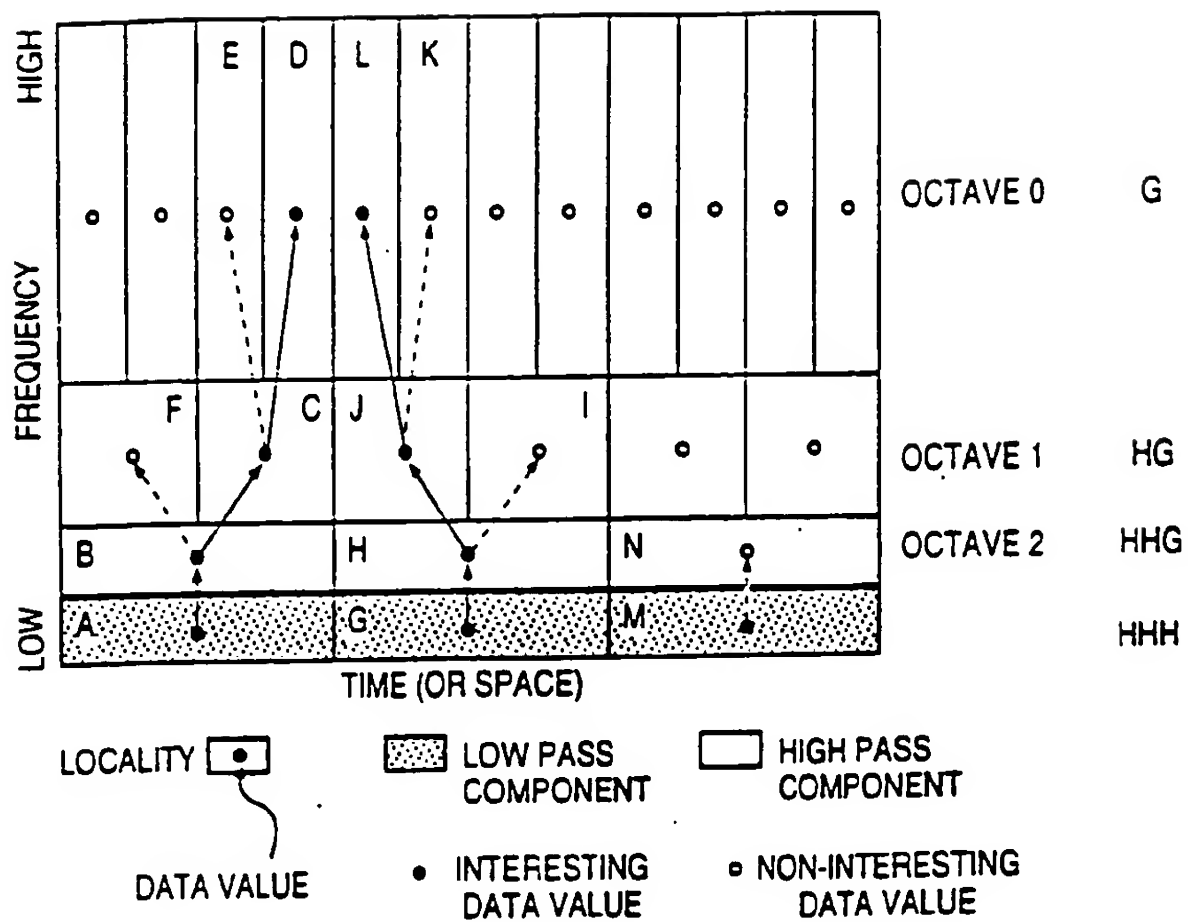


Fig. 23

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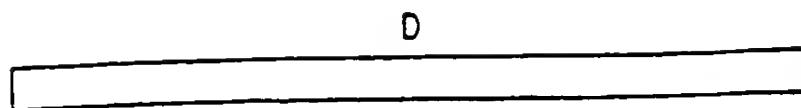


Fig. 24A



Fig. 24B

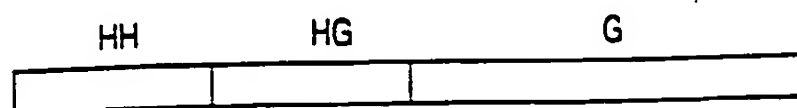


Fig. 24C

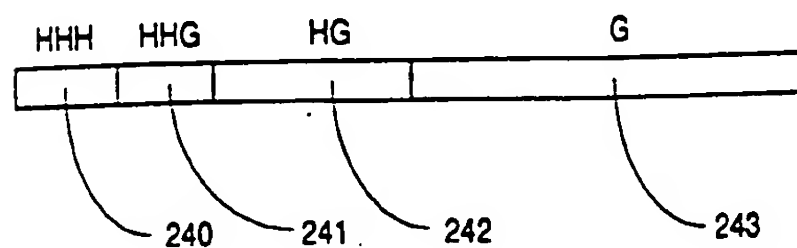


Fig. 24D

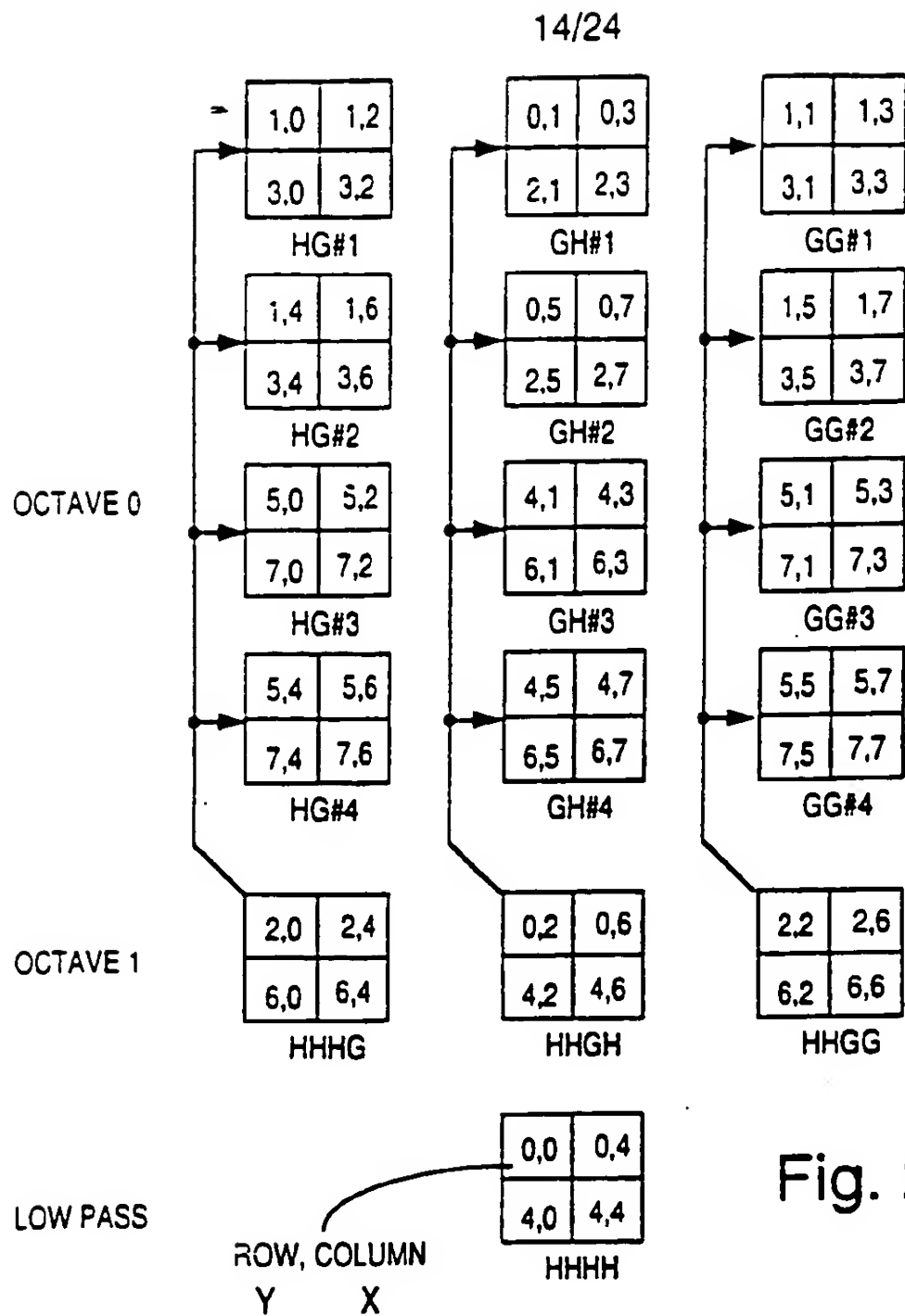
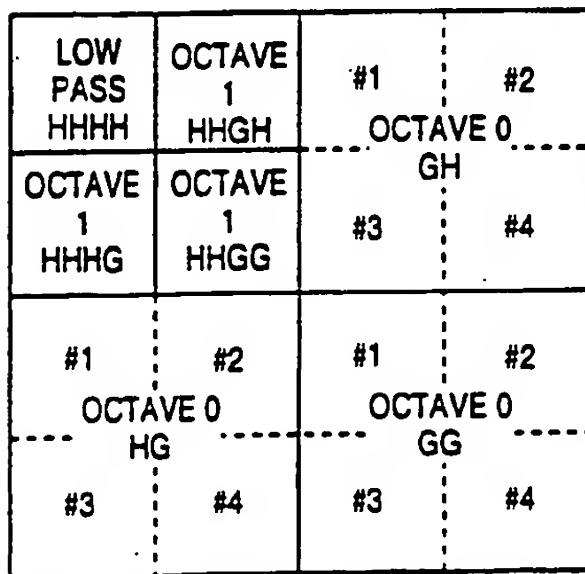


Fig. 25



PICTORIAL REPRESENTATION

Fig. 26

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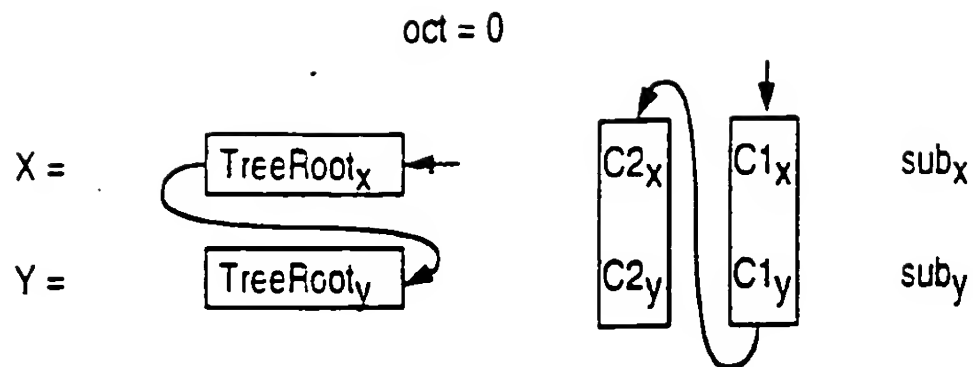


Fig. 27

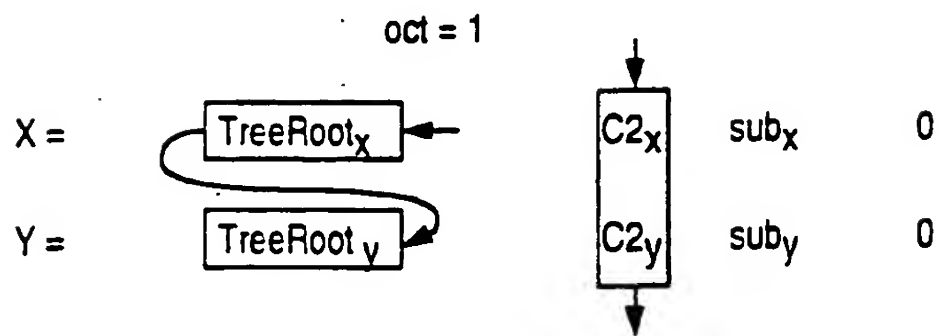


Fig. 28

| sub-band  |      | $\text{sub}_x$ | $\text{sub}_y$ |
|-----------|------|----------------|----------------|
| low pass  | { HH | 0              | 0              |
|           | { HG | 0              | 1              |
| high pass | { GH | 1              | 0              |
|           | { GG | 1              | 1              |

Fig. 29



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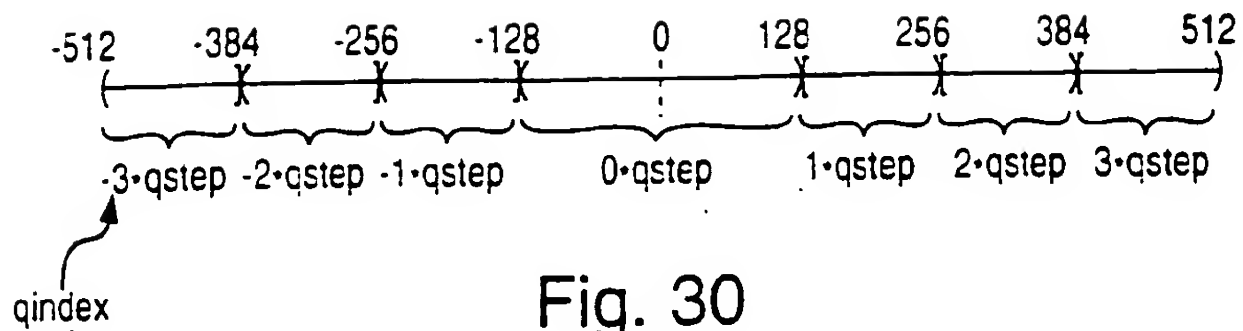


Fig. 30

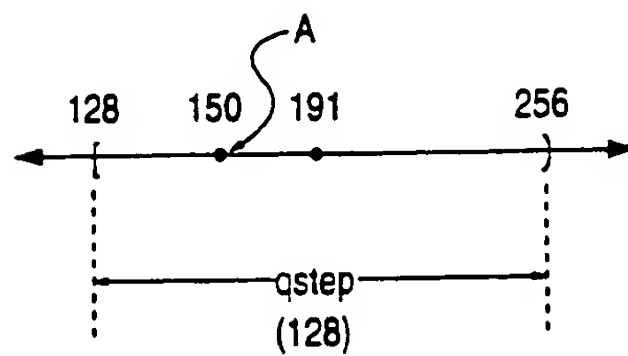


Fig. 31

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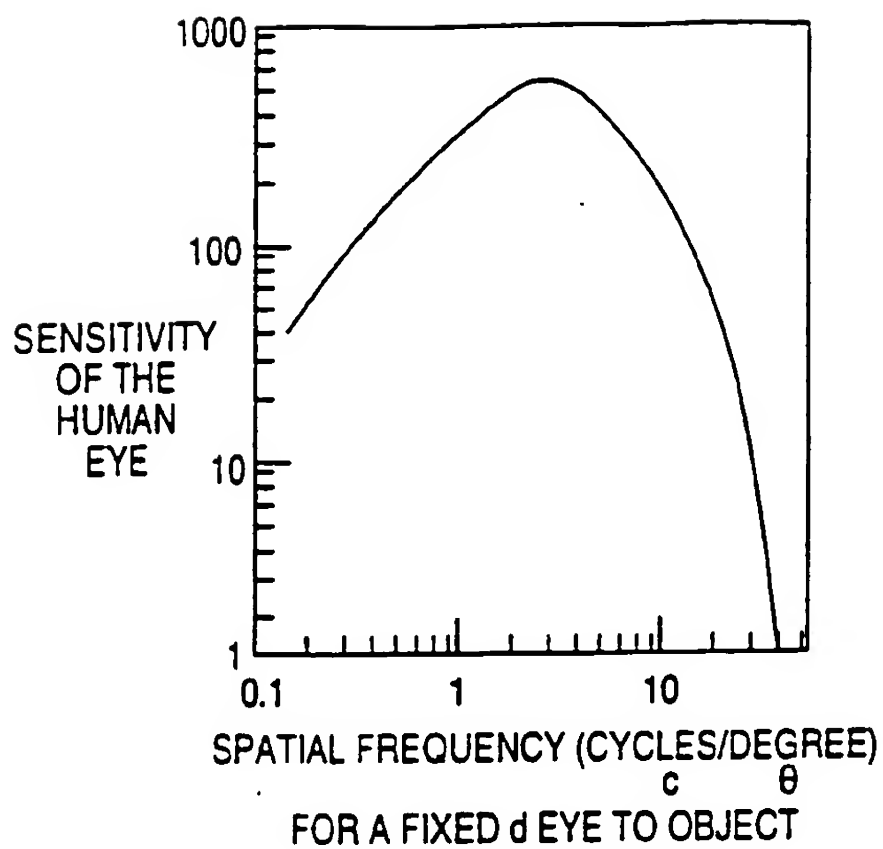


Fig. 32

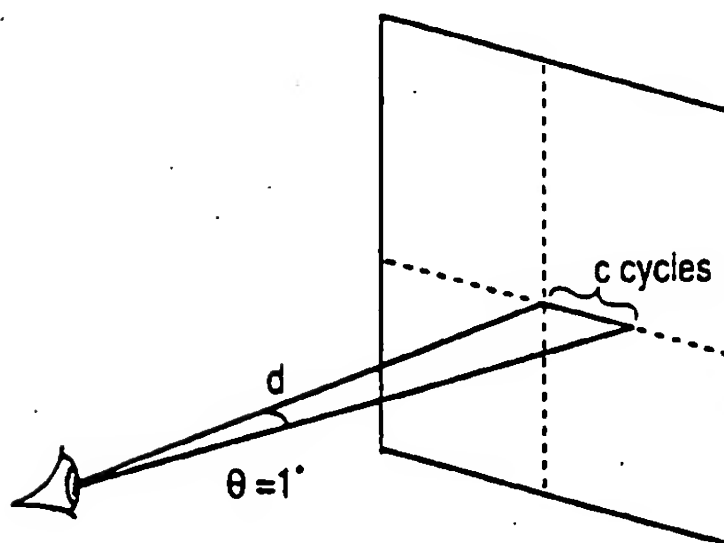


Fig. 33

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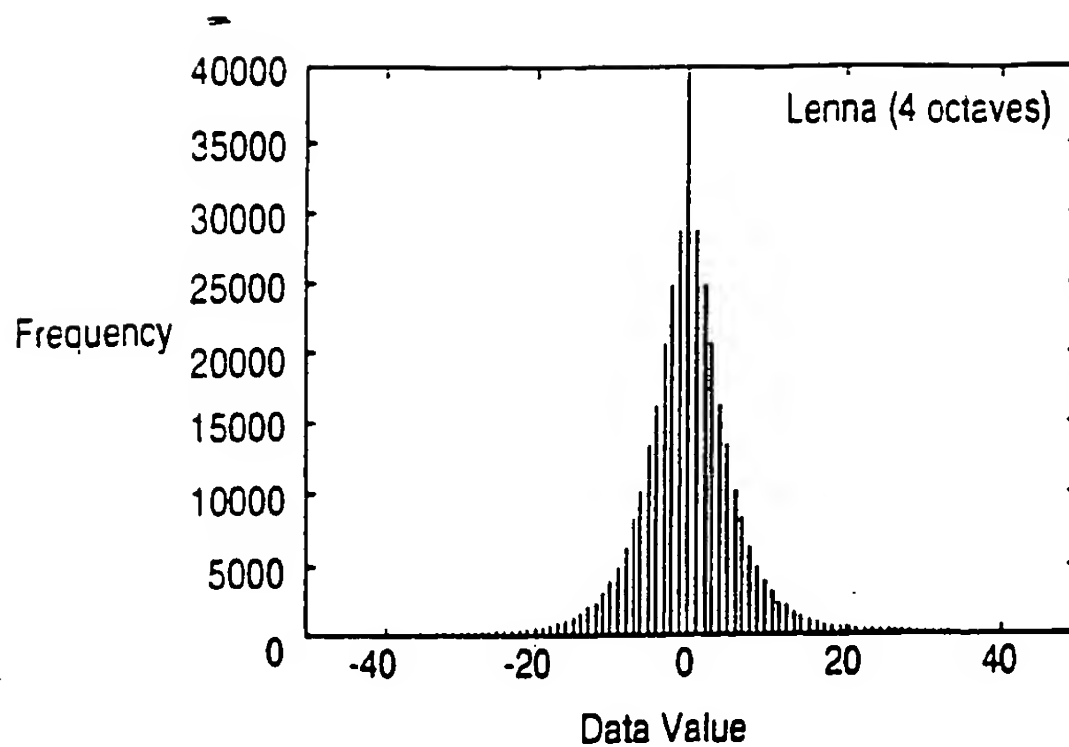


Fig. 34

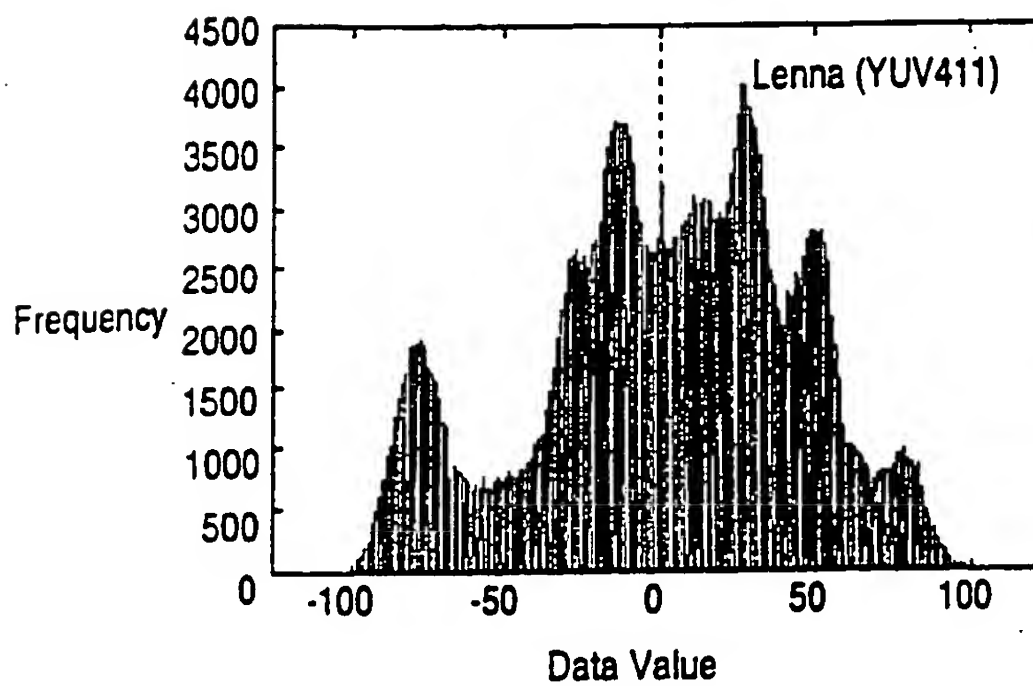


Fig. 35

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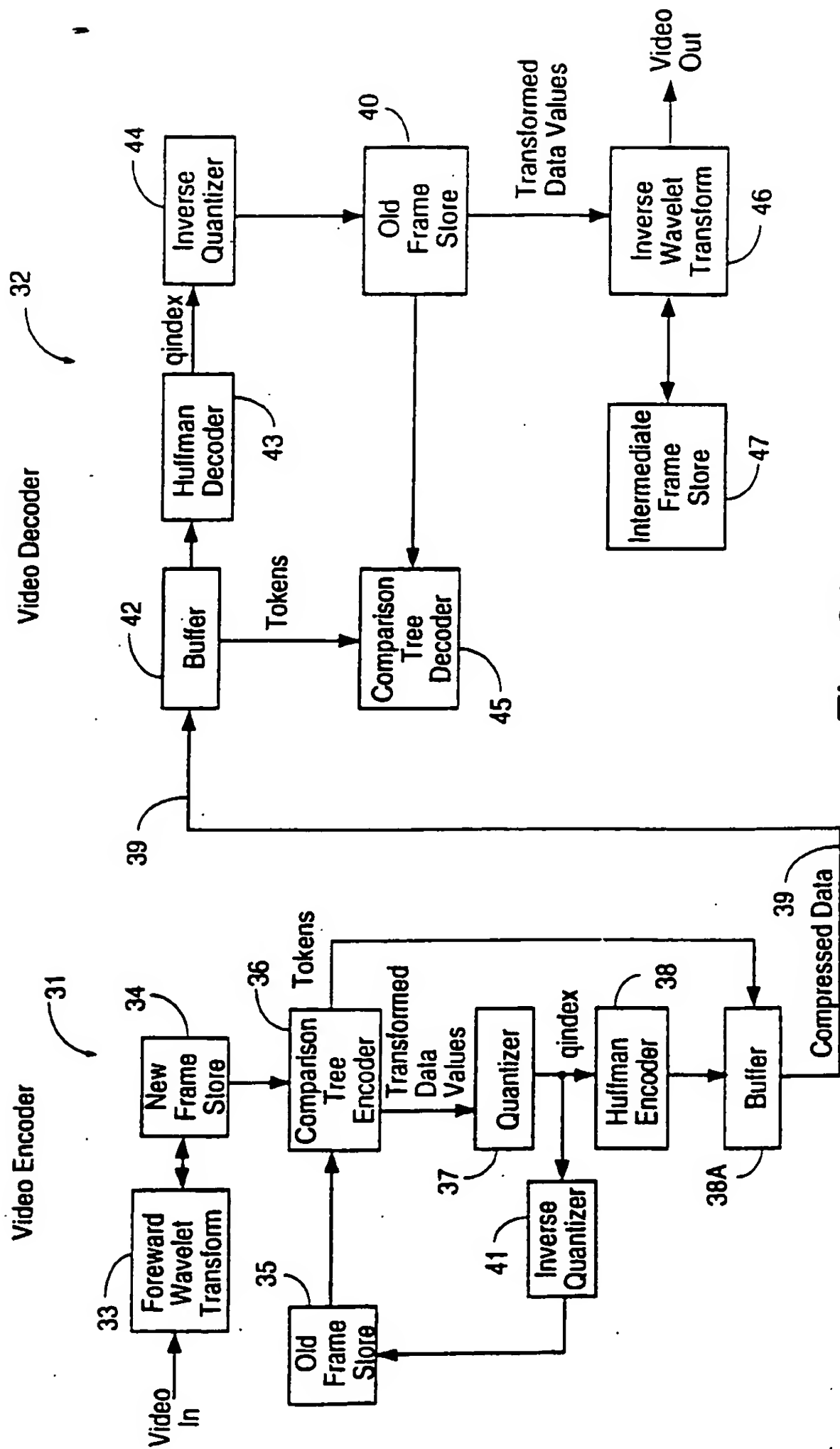


Fig. 36

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# MODES OF VIDEO ENCODER AND VIDEO DECODER

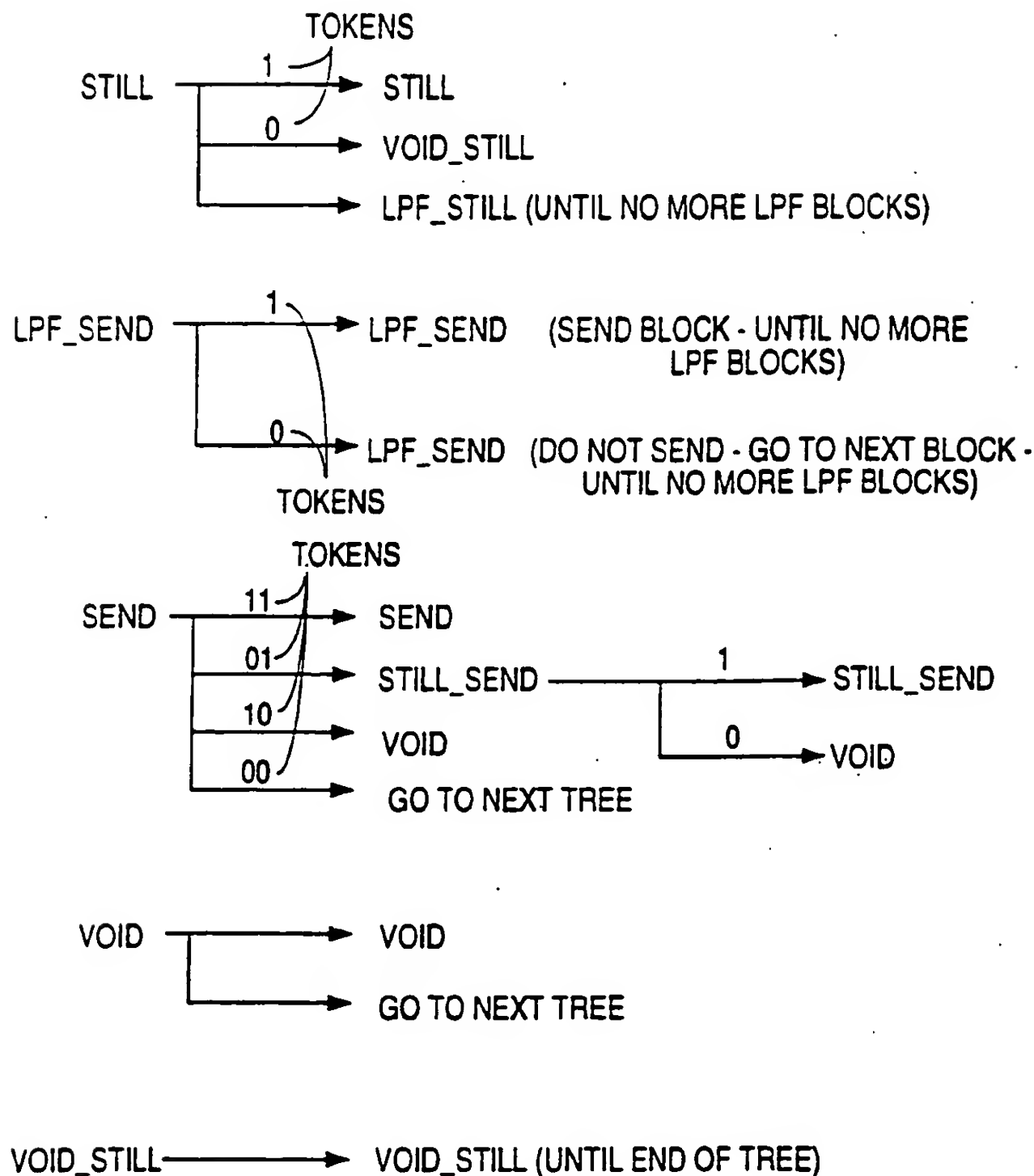


Fig. 37

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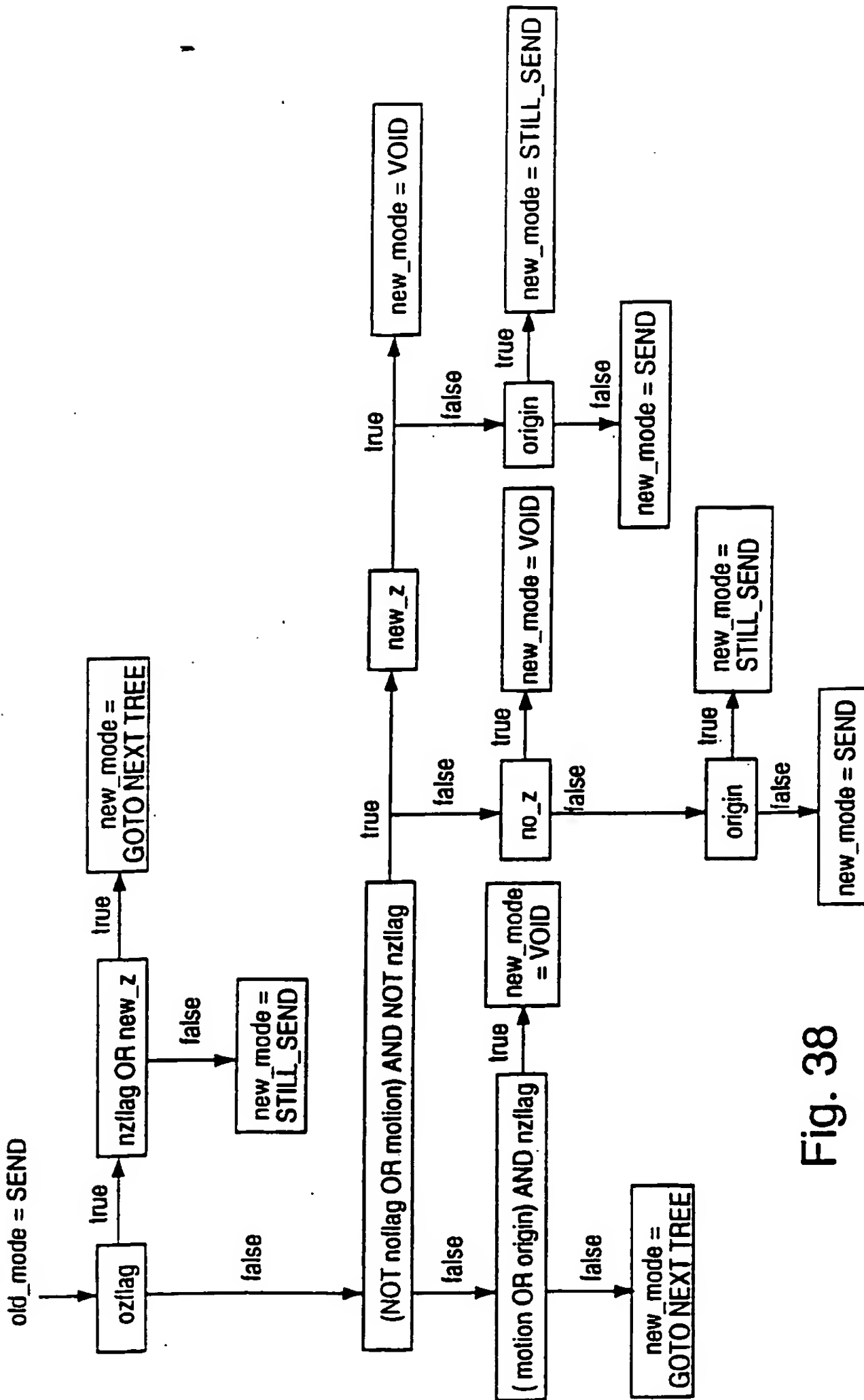


Fig. 38

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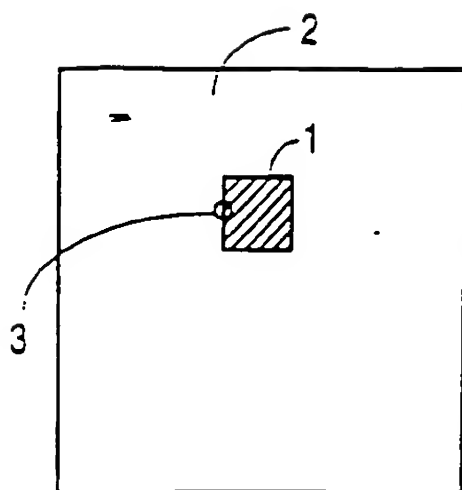


Fig. 39

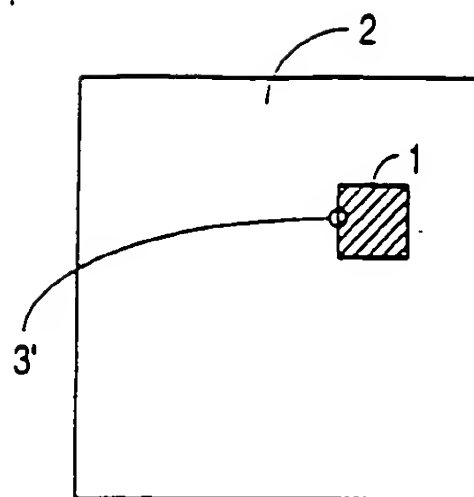


Fig. 40

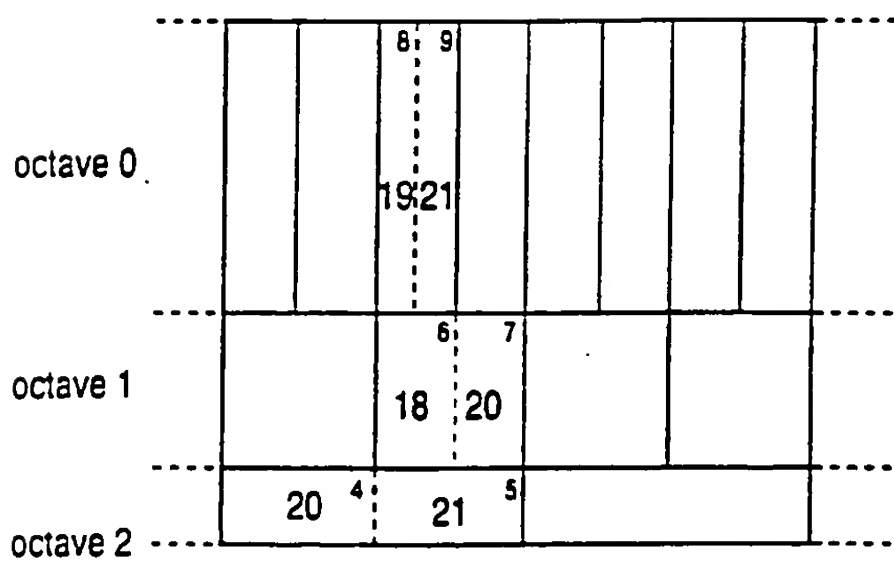


Fig. 41

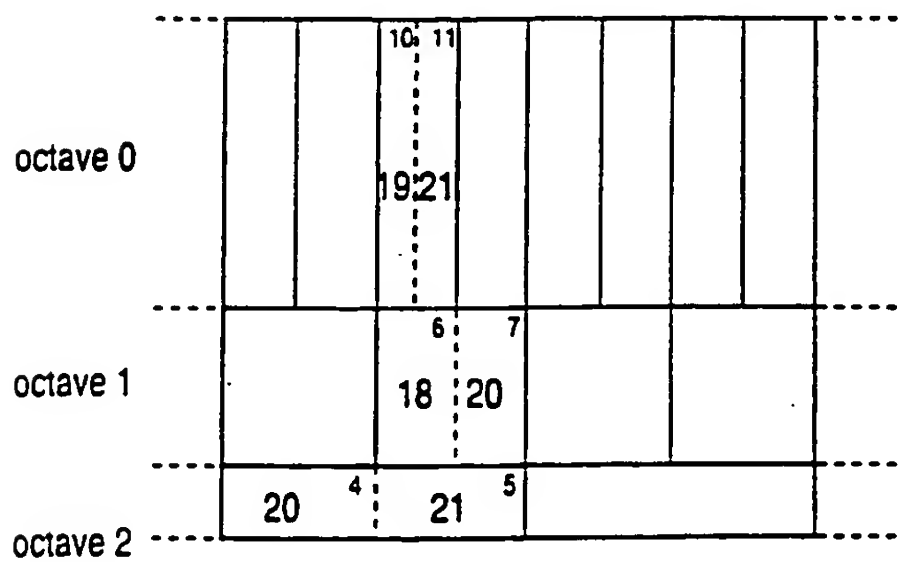


Fig. 42

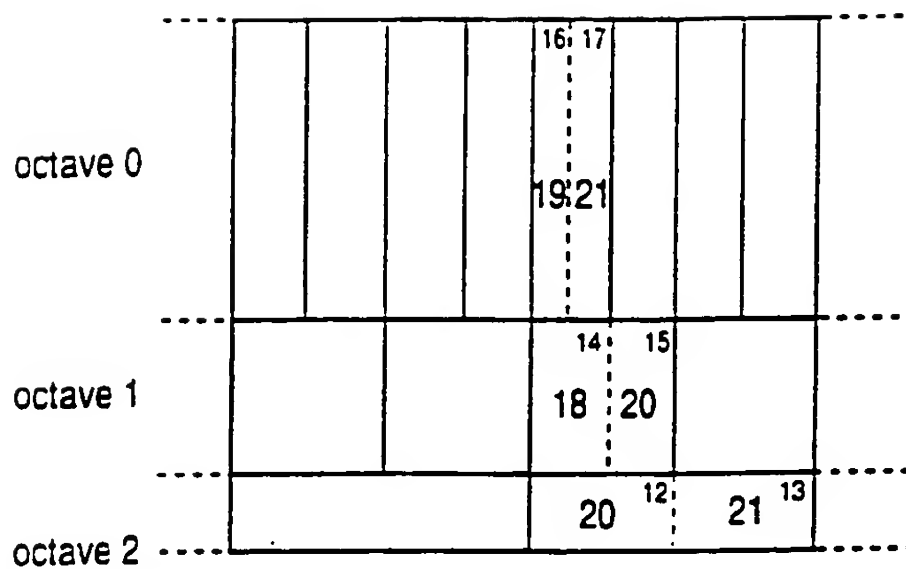


Fig. 43



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## VARIABLE - LENGTH TOKENS

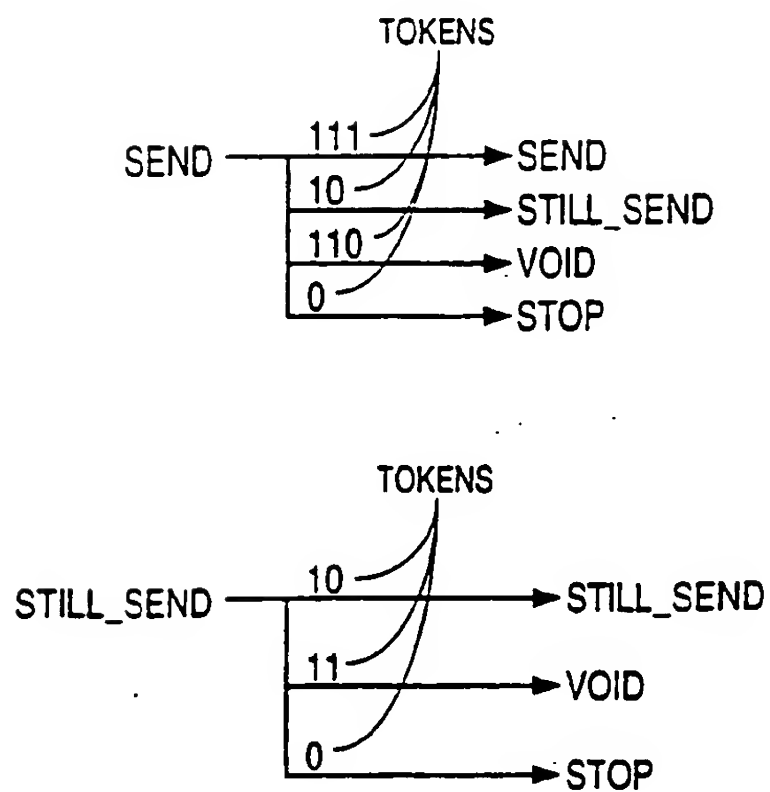


FIG. 44